Sky and TELESCOPE

In This Issue

New Projector for Navigational Stars

Far-Flying Meteor Stirs Speculation

Relativity . . . II

Our Nearest Stellar Neighbor

The Starry Heavens in November

Vol. 2, No. 1

NOVEMBER, 1942

Whole Number 13

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Sky and TELESCOPE

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The Editors Note . . .

IN this issue, which begins our second year since combining The SKY and *The Telescope*, a new kind of star chart is introduced, embodying some features we have long wanted to put into our monthly maps of the sky. Chief among these are: a triple horizon, whereby the chart can be used for all latitudes of observers in the United States and Canada; the names of the navigation and other well-known stars; Greek letter designations; some of the most readily observed clusters, nebulae, and galaxies.

Of course, there are star charts of various types, each with its own advantages. In a monthly journal, it is difficult to satisfy the needs and desires of everyone, but the new maps should serve more of our readers than have previous ones. Also, our new planet maps, which together cover the entire heavens visible from sunset to sunrise, will enable beginners to find the brighter constellations and star groups, as well as the planets and the moon.

This first chart has revealed several mechanical difficulties which we expect to overcome next month, with a consequent improvement in readability. Since the charts for succeeding months have not yet been drawn, they are subject to revision according to audience reaction, plenty of which we hope to receive from readers who use them regularly.

For obvious reasons, the mail service of our country is overburdened. Therefore, this and other publications may be late in reaching you. We endeavor to publish as early as is consistent with bringing you last-minute news of the astronomical world. If the first of the month passes before *Sky and Telescope* reaches you, we ask you to have patience. If for some reason, such as a recent change of your address, an issue fails to arrive at all, we shall be pleased to send a duplicate. However, notice of change of address sent to us well in advance should avoid this.

VOL. II, No. 1 NOVEMBER, 1942
Whole Number 13

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The Starry Heavens in November 20

BACK COVER: The well-known spiral nebula in Triangulum, M33 or N.G.C. 598, is at R.A. 1^h 31.1^m, Dec. $+30°$ $24'$. It is about one degree in diameter, second only in apparent size to the Andromeda spiral, but it is turned more nearly fullface to us. An "advanced" type spiral, the galaxy shows condensations and granular nodules and a comparatively inconspicuous nucleus. M33 contains an unusual number of blue supergiant stars, and has a total luminosity equal to 160 million suns; the mass is about a billion times the sun's. This galaxy is a member of the Local Group of galaxies, and is at a distance of about 720,000 light-years. It approaches our galaxy at about 180 kilometers per second. Its actual distance from M31, the Andromeda spiral, is only about 200,000 light-years, which appears in the sky as about 15 degrees.

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NEW PROJECTOR
for Navigation Stars

By James R. Benford

Bausch and Lomb Optical Company

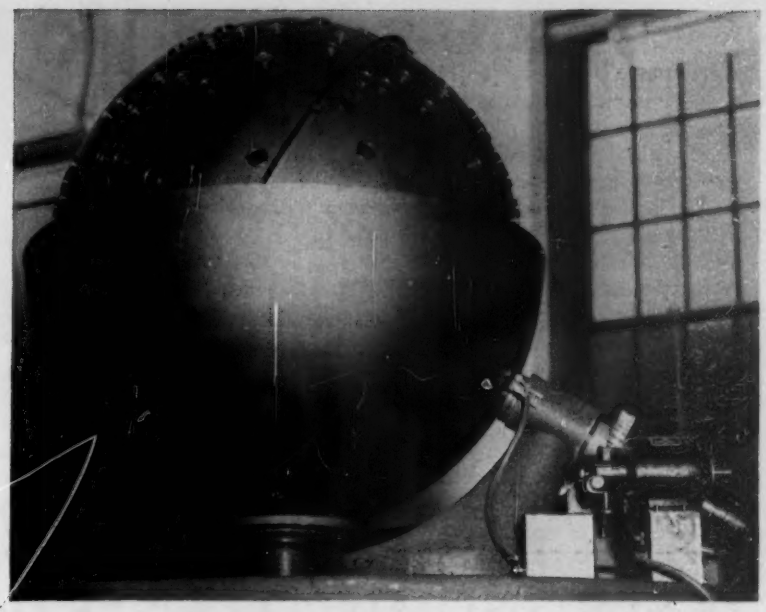


Fig. 1. The Bausch and Lomb artificial star projector, built for the U. S. Naval Air Station, Pensacola, Fla., completed, but with the guard for gears removed to show the mechanism of the gear drive.

CELESTIAL navigation is becoming increasingly necessary as the cruising range and altitude of airplanes are increased. It serves as a check on dead reckoning when marker beacons, radio beams, and landmarks are left behind. Basically, as described in an earlier issue of this periodical, celestial navigation consists of establishing lines of position and obtaining a fix by observing two or more celestial bodies or by taking several observations of the same celestial body.

The problem of presenting the true appearance of the navigational stars has long been a difficult one in the teaching of celestial navigation. Star charts which attempt to picture the celestial sphere on a plane surface either suffer from a distorted appearance or else show only a limited portion of the sky. Amateur astronomers can overcome these disadvantages by constant use of various kinds of charts, but in short courses in navigation it is often hard for men in the Services to gain true impressions of the form, location, and interrelations of the constellations from anything but the sky itself.

However, the United States Air Station at Pensacola, Fla., has recently installed a Bausch & Lomb artificial star projector which overcomes the difficulties of star charts, as well as presenting other advantages for the teaching of navigation. The instrument is located in the center of a hemispherical dome, upon which it projects images corresponding to 145 navigational stars. Students and instructor sit within the dome at a level slightly below that of the star projector. Room lights and projector controls are located near the base of the instrument, convenient to the instructor, as shown in the front-cover photograph.

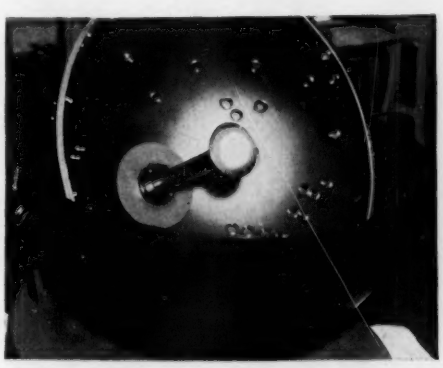


Fig. 2. Half of the large sphere is here removed to show the internal construction of the projector.

When the projector is in use, the room is darkened and the stars appear as points of light in a twilight sky, thus simulating the conditions under which sights against the visible horizon are most frequently made. With a completely darkened room, the dome is invisible and the illusion of the tremendous depth of space becomes very striking. The stars swing slowly across the face of the dome as the star projector rotates on its axis, 20 minutes being required for a complete rotation.

The instrument, shown in Figure 1, is essentially a multiple pinhole projector. It contains at its center a low-wattage light source with a compact filament. Surrounding this filament, and concentric with it, is a 3¼-inch sphere of spun copper. Drilled in this sphere at their proper locations are 145 small holes which act as the objects to be projected. Surrounding the inner sphere is another, 25 inches in diameter and containing 145 lenses. These project the pinholes on the dome to the proper positions in right ascension and declination.

Light source, small sphere, and large sphere rotate as a unit about an axis inclined 30 degrees to the horizontal, which corresponds to the latitude of Pensacola. A 27½-inch stationary hemisphere surrounds the lower half of the 25-inch sphere to act as an occulting device for all stars as they reach the horizon.

Figure 2 shows the appearance of the interior of the instrument, one half of the larger sphere being temporarily removed. The projector is rotated at a speed of 1/20 r.p.m. by means of a geared-down synchronous motor. The axis of rotation which supports the projector is hollow to permit a cooling draft of air to be blown around the light source by a blower located at the lower end of the axis. Two ball-bearing races, one of which acts as a thrust bearing, support the projector and permit it to turn smoothly and easily. Electrical connections are made through commutators built into the supporting axis. For locating the lens positions on the large sphere, a special table was built on which a series of guiding roller bearings were arranged in a circle of a size to accommodate the flange of either half of the large sphere, as shown in Figure 3. The bearings permitted easy and accurate rotation of the half-sphere, and a large semicircular yoke, mounted on trunnions, carried an engraving point for marking the right ascension. The diameter at the flange was first carefully measured and divided into 360 parts—one degree each. The declination was obtained by linear measurement from the flanged diameter.

Figure 4 shows the method of locating

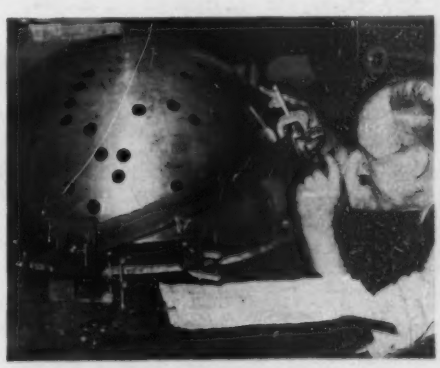


Fig. 3. Locating the lens positions. H. Bodmer, instrument maker who built the star projector, is shown scribing the vertical line which marks right ascension.

the small-diameter holes in the inner sphere. The latter is shown mounted on the main axis of the projector, its axis being trued up in the lathe. The lathe was equipped with a divided circular head which controlled the right ascension. A special guiding block was made for a small high-speed electric drill, which permitted it to be guided radially toward the sphere in the manner shown in the figure. This block was mounted on the regular horizontal divided circle ordinarily used for guiding the cutting angle on the lathe. This divided circle thus controlled the declination.

The holes in the inner sphere are of three different sizes: 3/1,000, 5/1,000, and 7/1,000 of an inch in diameter, thus representing three star magnitudes.

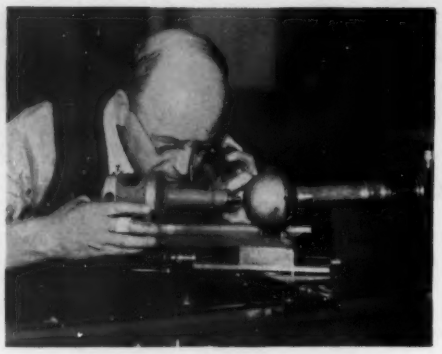


Fig. 4. Locating the holes in the inner sphere.

Ordinarily, a change in size of an object does not change its apparent brightness, but here we are dealing with objects too small for the eye to detect any size differences among them, and since more light goes into the images of the larger holes than the smaller ones, they *seem* brighter to the eye. All of the projected stars appear to be of the same size, giving a very realistic appearance.

The picture on the front cover shows the star projector in actual use. A flashlight pointer is used to point out stars and constellations. This is a distinct advantage over outdoor instruction, where pointing out stars to large groups is often an indefinite and unsatisfactory procedure. And, of course, the star projector is independent of weather and of the season of the year, enhancing its value in pilot training today, when speed is so essential.

ASTRONOMICAL ANECDOTES

A SURVIVAL; CHAOS AND POLITICIANS; CELESTIAL DISAPPEARANCES

LAST month, the query of a correspondent concerning an old telescope was left unanswered, except to say that the instrument had probably not survived. Another letter, from J. W. Draper, of Warren, Ohio, tells of another old instrument. In the *Western Reserve Chronicle* for February 3, 1831, there is a description of a "new telescope for Yale College."

The instrument had been long delayed, but was at last "mounted on its stand in the philosophical chambers. It was made by Dollond, of London . . . . It is an achromatic telescope, of 10 feet focal length, and five inches aperture . . . . The tube is of brass . . . ."

Mr. Draper asks if we know whether the telescope is still in existence. It is indeed, and anyone may see it by going to the astronomical section of the Franklin Institute in Philadelphia. Only the brass tube is displayed there; strangely enough, it is segmented and collapsible, like a spyglass.

I remember having discussed with a botanist the relative ages of his science and mine. He recalled to me a story of three men thrown together by chance in the lounge of a club. One was an astronomer, one a geologist, and one was a politician. The astronomer was insisting that his was the oldest science, and that man's first unpractical endeavor was the study of the sky by night. The geologist insisted that his science, too, had been pursued by men from very early times, but that on still another score it reached farther back into the past than did astronomy, for geology traces the evolution of the earth from chaos. At this point, the third man joined the conversation, stating that his vocation then must be the oldest, for if there were any chaos, politicians created it. Which reminds us that there is an election day this month.

The editor of *Sky and Telescope* has sent me a publication of the Yakima Amateur Astronomers, in which reference is made to a strange "disappearance" of the moon. There are other instances of disappearance and change on record. In R. H. Allen's *Star Names and Their Meanings*, page 130, there is the statement that, according to Montanari, Gamma Canis Majoris disappeared entirely in 1670, and was not seen until 1693, by Miraldi! That would be strange indeed, if Montanari really said it; I have not been able to verify it. That is one great fault many find with Allen's book—proper references are not given, so one has difficulty in knowing how much of the book to believe.

On page 102 of Allen, it is said that Schmidt observed on March 21, 1852, that Arcturus had lost its usual fiery tinge, and the observation was confirmed by Argelander and Kaiser. Then there is often brought up as the reason for the naming of Cor Caroli the statement of the court physician, Sir Charles Scarborough, that on the eve of the king's return to London on May 29, 1660, the star had shone with special brilliancy. Couldn't this have been merely a bit of attempted flattery, with no observation behind it?

There are some authentic instances of objects having become lost. In any recent issue of *Kleine Planeten*, the annual catalogue and ephemeris of minor planets, one can find a list of those not seen for several oppositions. Scylla (No. 155) has not been seen since 1875, when it was discovered by Palisa. Aethra (No. 132), discovered by Watson in 1873, was observed for only 22 days, then was lost, not to be seen again until 1922. It now has been brought under control, largely through the efforts of Paul Herget, of the Cincinnati Observatory. Incidentally, it should be generally known that Watson "endowed" the 22 asteroids he discovered, so they are assured of perpetual care. The estimable work of the Students Observatory of the University of California ensures that these asteroids will probably not become lost.

I believe it is not general knowledge that one of Jupiter's satellites has been somewhat elusive. I remember discussing this with the late Dr. E. W. Brown a dozen years ago. He was much amused at my shocked expression when he told me of the efforts being made to find Jupiter VIII, and took pleasure in telling me some of the story. The satellite was discovered by Melotte at Greenwich in 1908, and was observed at each opposition until 1917. Then it was not seen until 1922, when Knox-Shaw, using a search ephemeris by Jackson, managed to photograph it. It was seen again in 1923, but was once more lost. Prof. Numerov, of the Astronomical Institute of Leningrad, assigned the problem in 1929 to Miss Boeva; she was to begin with the observations of 1916, and compute the orbit by mechanical quadratures, the usual procedure for objects which are greatly perturbed. She at last was able to communicate an ephemeris for the period November, 1930, to March, 1931. As a result of her work, Jupiter VIII was found at Mt. Wilson on November 30th, and at Yerkes on December 16th, 1930. The residuals were less than seven minutes of time in right ascension and 45 minutes of arc in declination, and Prof. Brown considered that a triumph of mathematical theory, for a body of such high orbital eccentricity and inclination.

But would you have thought, offhand, that we should consider ourselves lucky to be able to find a satellite of Jupiter within a couple of moon-diameters of its proper position? R.K.M.

FAR-FLYING METEOR STIRS SOUTHWEST

BY OSCAR E. MONNIG, *Texas Observers*

A METEOR with a near record-breaking path moved from the region of northeast Texas to the far northwestern corner of the Oklahoma panhandle on the evening of August 7, 1942, at 9:30 C.W.T. The primary purpose of this note is to request carefully *measured* observations from any amateur or professional astronomers who were fortunate enough to witness this object.

The long duration gave one man, who was driving a car, time to realize what he was seeing and to turn and wake his little boy (asleep on the back seat) in time for him to see the end of the meteor! People called others from out of houses, or ran 50 to 100 feet to get intervening buildings out of the way, and actually saw the meteor emerge and keep going! This feature and the early hour of the warm, summer evening probably allowed the meteor to be seen by more persons than any other in this region for the last 20 years.

The meteor was remarkable chiefly for a path fully 500 miles long, and perhaps as much as 600 miles. It may have begun over the region of Paris, Tex., but there is strong evidence that it first became luminous between Shreveport and Texarkana. It required fully 20 seconds, and probably nearer 30 to 35, for the long trip across Oklahoma to the northwestern corner of Cimarron County, and there are some indications that the sub-final point may even have been in extreme southeastern Colorado (Baca County).

What is desired is the altitude and azimuth (in degrees) of the point on the path first seen, and the same for the point last seen. Estimates will not help much, as we already have approximately 140 general reports on the meteor from the northern half of Texas and from various Oklahoma points, as well as some from Kansas. The earlier portions of the meteor's path should have been visible from parts of Louisiana and Arkansas, while the end portions should have been seen from corners of New Mexico and Colorado.

While the writer strongly prefers field surveys to mail surveys in the case of investigations of this sort, current conditions limit our work largely to the mails. In addition to many reports worked out by mail as well as possible, we have carefully measured "on-the-spot" observations at Ft. Worth, Breckenridge, Albany, Stamford, and Quanah, Tex. A great majority of our reports are from the south side of the path and are very generally similar, but a few from Oklahoma City and Wichita give a good basis for certain delimitations of the path. Dr. Ford E. Bridges, of Tulsa, Okla., in particular, sent an excellent observation.

Recently we have secured a group of reports from the Oklahoma panhandle counties, indicating definitely that the meteor passed a short distance (less than 20 miles?) north and east of Guymon, Okla. No reports of detonations have come in, and the evidence for possible landing of any meteorite is slight. Nevertheless, so very little is known about these long, slow meteors, that anything may be considered possible, and nothing should be ruled out until several such meteors have been very completely investigated.

The meteor was not extremely bright, and is judged roughly to have been of magnitude −4 (equal to Venus) from points about 100 miles from the first part of the projected path. Nearer the end and more nearly under the path it may have been a mild "ground-lighter." It was not the very red, glowing-ember type we generally associate with long-pathed, slow-moving meteors, and was pretty consistently reported as golden, yellow, or some similar color. It carried a tail along with it and left an evanescent train that must have been some 30 degrees in length as seen from many places, but the train's duration hardly exceeded five or 10 seconds.

The extremely long path produced most unusual apparent paths for observers. In northeast and north-central Texas, people saw a meteor with an apparent path length of from 70 to 140 degrees of arc! The true slope of the meteor was obviously small—it had to be coming in at a low angle with the earth's surface to last so long. As a result, the path was nearly horizontal for many observers, and the meteor seemed to go on and on and on. Those who witnessed the extremely long arcs saw the object rise slightly at first, come to an "even keel," and then slowly fall.

If you live in the area shown on this map, you may have seen the brilliant meteor of August 7th. Its path is shown roughly by the dashed line extending from southeast to northwest.

For those near the beginning region, the very great distance which the meteor soon attained caused its apparent brightness to diminish markedly—a simple calculation indicates a decrease of several magnitudes on account of the change in distance, and there is the additional factor of atmospheric absorption. For those fairly near the path, there should actually have been marked differences in the apparent angular speed. Near the end region, people saw the meteor rise like a rocket out of the southeast, attain a high altitude, and fade low in the northwest.

It should be noted that the time on a Central standard basis was really only 8:30 p.m., and on a Mountain standard basis (southeastern Colorado) 7:30 p.m.; there was actually a slight amount of twilight still present, especially in the more western regions involved.

The Texas reports were well scattered, but stop short on the South Plains, south of Lubbock, and at the eastern edge of the panhandle. Observers on the fringe of this region report clouds which the meteor went behind or from which it emerged, resulting in a lack of returns from the best region for observations of the end point. The clouds were broken to scattered, and were sufficiently absent in the western Oklahoma panhandle counties to get a number of reports from there.

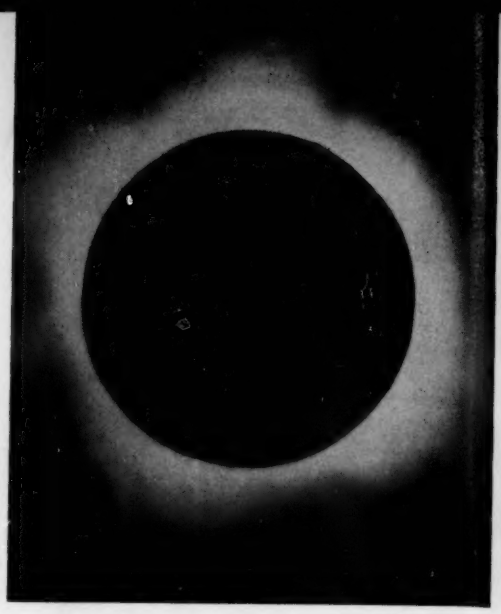
Near its beginning, the meteor was probably at least 80 miles high. We have appealed to some half a dozen sources for observations from extreme eastern Texas or Louisiana, with no results. At its end point (only 15 miles high?) it would be less widely observed but still visible. Nevertheless, we have had the same lack of reports from southeastern Colorado, and even Dr. H. H. Nininger, in Denver, who has a wide net spread for such objects, got nothing from his own state! He has helped supply us with some Kansas reports, but we are still most anxious to hear from the "other side" of the meteor's end. Up until now (October 1st) the sub-final point has been constantly receding, much like the pot of gold at the foot of the rainbow.

ED. NOTE: The author's address is 1010 Morningside Drive, Fort Worth, Tex.

RELATIVITY . . .

and Its Astronomical Implications

By Philipp Frank, *Harvard University*



The fortuitous phenomenon of a solar eclipse makes possible one of the most spectacular proofs of Einstein's principle of equivalence.

PART II

4. The homogeneous field of gravity and Einstein's principle of equivalence

EINSTEIN'S theory of the phenomena occurring in a homogeneous field of gravity can be explained with very little mathematics, and it leads directly to the results of general relativity which are of interest in astronomical matters, such as the curvature of light past the sun and the Einstein shift in the spectrum of the companion of Sirius.

The homogeneous field of gravity, with which Einstein began, is a field or domain in which the action of gravity is assumed to take place with the same intensity and in the same direction at all points in the domain. For practical purposes, and to enable us to visualize the principles involved, we may take a room on the surface of the earth. In such a room, the difference in the distances from the top and bottom of the room to the center of the earth may be ignored. The force of gravity may therefore be considered as directed vertically downward and producing in all points of the room the same acceleration of gravity, usually called g; its numerical value at Boston is nearly 980 centimeters per second each second, or nearly 32.2 feet per second each second.

In this simple field the inseparability of the inertial and dynamical components of falling bodies, as discovered by Galileo, can be formulated in a particularly simple and impressive way, without recourse to Newtonian gravity which increases with the mass. The reader is here urged to review the first installment (October, *Sky and Telescope*) to be sure of his understanding of the geometrical and dynamical components of a motion, and of Newton's interpretation of the strange behavior of falling bodies.

For the purposes of argument and illustration, let us neglect the motion of the earth with respect to the fixed stars —its rotation and revolution are considered to have ceased for the moment. Also, regard the room as rigidly connected with the earth. But the earth is now an inertial system, and so the room becomes one also: with respect to the room the geometrical component of every motion is rectilinear and with constant speed. Let us denote the room system of reference by E. Relative to E a falling stone is observed to describe a vertical straight line with a constant acceleration g. A launched projectile describes a parabola which is composed of a vertical uniformly accelerated motion (which exists also in the case of the falling stone) and a rectilinear motion with constant speed in the direction of the initial velocity. (See diagram, Part I, page 11.)

These facts are described in our traditional Newtonian mechanics by saying that E is an inertial system and that the action of a force called gravity produces the acceleration of falling bodies and the curvature of the path of a projectile. We have seen, however, that the observable facts in this room do not enable us to separate from the inertial motion the motion due to the gravitational field—the usual method of changing the mass to change the acceleration fails to work. Regardless of the mass, the downward acceleration observed is always the same. This is not a characteristic of a dynamical motion, and is directly contrary to Newton's concept of the action of a force on a mass, or of the effect of a change of mass in a field of force.

Why not then, describe the observed facts by saying that *E is not an inertial system*, but is moving "upward" with a constant acceleration g with respect to a really inertial system which we call J. (As a matter of one thing relative to another, we could also say that the inertial system has an acceleration g downward with respect to E.)

With this simple thought—that E is not an inertial system—we can describe in quite a different way all the phenomena in the room traditionally ascribed to gravity. Thus, a falling stone does not fall with respect to J, for J has with respect to E the same acceleration as the stone. As far as E is concerned, the stone and J fall together, and the stone is fixed with respect to J. The projectile, similarly, does not fall with respect to J, but it does travel along a straight line in accordance with its initial velocity. Briefly, with respect to J, all bodies in the room E travel along straight lines with constant speed, that is, they all

A Summary of the First Installment

NEWTON'S laws of motion are correctly considered in terms of acceleration and mass. Lack of acceleration is shown by constant speed in a constant direction. Newton's basic principle is that acceleration is inversely proportional to mass, with "force" a proportionality factor: as the mass increases, the acceleration becomes smaller in a constant field of force.

If the force is zero or the mass infinite, the acceleration is zero. This means, the motion is rectilinear with constant speed. The geometrical form of the orbit is independent of the value of the mass (provided the mass is sufficiently great).

This *geometrical* path of an infinite mass is a straight line and of uniform speed only if referred to a certain system of reference, which is called the *inertial* system. This system is in a first approximation the system of the fixed stars. In some other system, the geometrical path may appear curved, or it may appear that the mass has an acceleration. (This thought is directly applied to gravity by Einstein, but not by Newton.)

But when "forces" act on a mass which is not infinite, a dynamical component is added to its geometrical motion. In an inertial system, this is easily distinguished because it is either curved or non-uniform, whereas the geometrical component is neither. But in any other system of reference, the distinguishing becomes more difficult, and must be done by varying the mass, to see how its acceleration changes. Increasing the mass to infinity will make its motion purely geometrical.

Galileo had looked for the dynamical component in falling bodies, by changing their masses, but he obtained the peculiar result that the acceleration of a falling body is 32 feet per second each second regardless of its mass. This did not fit well with the ideas of the relation of mass and acceleration, for if a *constant* force were acting on the masses, the heavy ones should be accelerated more slowly, and take longer to fall from a given height.

Newton accounted for this apparent disagreement by assuming that the force of gravity must be variable—that it must increase with the mass, and so massive bodies, pulled down by a greater force, fell as fast as light ones. Then the disagreement disappeared in "equating the equations."

Einstein regarded this "inseparability" of the inertial and dynamical components as the essential feature of the gravitational motion.

have purely geometrical paths. No dynamical "gravity" exists relative to *J*. However, since *E* is conceived as moving upward with respect to *J*, the stone appears to strike the floor of the room, exerting a pressure. But in our new description, the impact is not due to the falling of the stone, but to the acceleration of the floor *E* with respect to the inertial system *J*.

We now can understand the difficulty in separating the dynamical component of a falling body's motion from the geometrical. There is no really dynamical component at all! At least, if we accept the Einstein explanation, the observed motion is geometrical, but it is with respect to a system which is not inertial—that is, which has a motion of its own. As we have considered before, the geometrical component of motion with respect to a non-inertial system is curved or non-uniform or both.

Therefore, all our experience about bodies moving in the homogeneous field of gravity in a room can be described in two ways, one according to Newton, the other according to Einstein:

1. *E* is an inertial system in which a homogeneous field of gravity is acting downward, imparting to every mass *m* an acceleration *g*; hence, according to Newtonian laws, gravity exerts a force *mg* upon this mass.

2. *E* is not an inertial system, but is moving upward with respect to some other system *J*, which is inertial; hence, without need for postulating any force, the paths of projectiles are neither rectilinear nor uniform, so they appear to have an acceleration.

This double way of describing one and the same fact is possible because the gravitational motion cannot be separated from the inertial one. We can now easily understand how Einstein formulated his famous *principle of equivalence* in his original paper on gravitation, published in 1912 when he was teaching theoretical physics at the University of Prague. He stated that a homogeneous field of gravitation is "equivalent" to an accelerated motion of the room *E* with respect to the inertial system. This is evident in the case we have just considered, for there it is only a reformulation of the Newtonian laws.

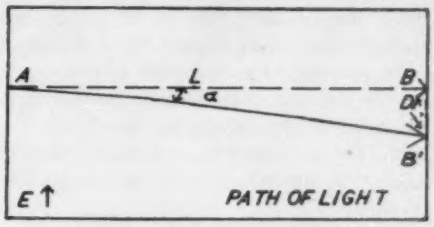
Einstein, moreover, ventured the hypothesis that whatsoever experiments we perform in our room *E*, the effect of the homogeneous field of gravitation is always equivalent to the effect of an "upward" acceleration of the room relative to an inertial system without any field of gravity being in action. This hypothesis has to cover not only the motion of projectiles and similar phenomena, but also all optical and electromagnetic events in this room. Since no influence of gravity upon optical phenomena had been discovered before Einstein, this hypothesis opened the way for a new type of prediction. We shall see that several interesting conclusions indeed can be drawn about the action of gravity upon light rays and light waves, and that they can be tested by astronomical observations.

5. The deflection of light rays by gravity

LET us consider our room *E* as having an acceleration *g* upward with respect to the inertial system *J*. There may be a small hole *A* in the left-hand wall through which a beam of light enters in a horizontal direction (parallel to the floor). The fundamental law of optics says that if a light ray has an initial direction relative to an inertial system it will keep this direction unless deflected by reflection, or refraction, or diffraction. Our light ray would therefore remain parallel to the floor of room *E* if the room were at rest relative to the inertial system *J*, and the light ray would then strike the opposite wall at *B* at the same height as it entered at *A*. But while the light was traversing the room the latter has moved upward by the distance *BB′*, so the striking point is not *B* but *B′*.

If we call the distance across the room *L* and the speed of light *c*, then the time required for the light to traverse the room is L/c (assuming the room to be a vacuum). The distance traversed by the room *E* during this same time is $\frac{1}{2}gL^2/c^2$, so *B′* is lower than *A* by this amount. According to the principle of equivalence, we can describe the same phenomenon by saying that *E* has during the whole time been at rest relative to the system *J*, but that there is a field of gravity imparting to all masses the acceleration *g*. Then a light ray traversing a horizontal rectilinear path of the length *L* (perpendicular to the force of gravity) is bent downward by the distance $D = \frac{1}{2}gL^2/c^2$. The angle α, by which the ray is deflected, is easy to calculate because of the immense speed of light. For this reason *D* is very small, but *AB′* is an arc of a parabola because of the uniform acceleration of *E*. A simple geometrical calculation shows that $2D=\alpha L$, so we have finally $\alpha=gL/c^2$ (radians[3]).

This means, then, that a light ray traversing the distance *L* normal to the force of gravity is deflected by the angle gL/c^2. If the light ray is not exactly



The path of a ray of light in a gravitational field.

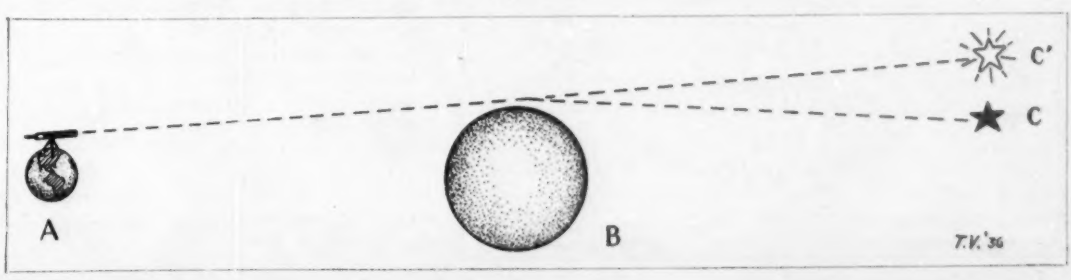
normal to the field of gravity, but makes an angle ϕ with the horizontal direction, the distance *L* has to be replaced by its projection on the horizontal direction, namely $L \cos \phi$. The angle of deflection of a light ray which traverses a field of gravity under an angle ϕ with the normal to the field is

$$\alpha = \frac{gL \cos \phi}{c^2} \text{ (radians)}.$$

We can easily carry out a rough estimation of the value of α under the most favorable conditions which can be found on earth. We take for *g* the approximate value 10^3 cm./sec.^{2}, close to its average value on the surface of the earth. For *L* we take the length of an arc from the pole to the equator, since a meter is by definition a 10-millionth part of that arc; therefore, *L* is 10^9 cm. The speed of light in a vacuum is 3×10^{10} cm./sec. Therefore, our angle of deflection is approximately 10^{-9} radians. There are about 2×10^5 seconds of arc in a radian, so the deflection is about 1/5,000 of a second of arc.

Since such a small angle cannot be measured by any terrestrial experiment, Einstein suggested that we investigate the possible deflection of light rays by the gravitation of the much more massive sun. To estimate this deflection, we apply Newton's formula for gravitation between any two bodies in the universe, namely $g = kM/r^2$ (*k* being the so-called "constant of gravitation" of the value 7×10^{-8} cm.^{3}/grams sec.^{2}). As

[3] *Radian:* the angle subtended at the center of a circle by an arc equal in length to the circle's radius.



Because of the deflection of light in a gravitational field, starlight passing the sun is bent toward it. Therefore, we observe stars near the sun, B, to be displaced outward from C to C′.

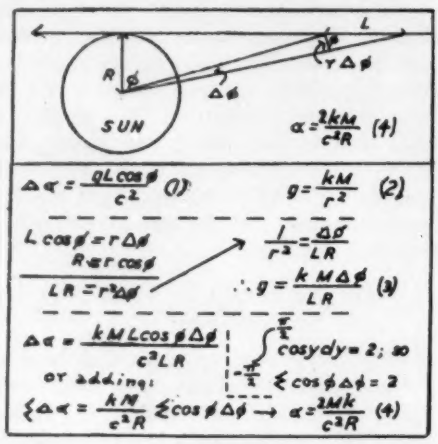
explained in most astronomy texts, the value of the acceleration of gravity at the surface of the sun can be roughly computed by means of this formula and the assumptions (close to the exact figures) that the mass of the sun is 300,000 times the earth's and its radius 100 times the earth's. The resulting g on the sun is 30,000 cm./sec.^{2} Substituting this value for g and 100 L for L in our formula for α, we obtain for a beam of light passing from the pole to the equator of the sun a deflection 3,000 times as great as for a similar beam on the earth; α is, therefore, of the order of 3/5 of a second of arc, an observable quantity.

However, in the case of light from the stars passing the sun, the actual deflection is computed differently, as the rays do not travel along an arc from pole to equator, as imagined in our rough estimates. The action of "gravity" on starlight passing the sun varies for different parts of the ray and may be computed from the formula

$$\alpha = \frac{2kM}{c^2R},$$

in which M and R are the mass and radius of the sun, respectively. Its derivation is given in the accompanying diagram. Substituting numerical values, we obtain the deflection $\alpha = 0''.87$, so the rays are, roughly, deflected by one second of arc in passing the sun.

This value of the deflection is the result of two basic hypotheses: 1. The equivalence or inseparability of the effect of gravity from the effect of inertia. 2. Newton's law of attraction. However, Einstein found that the consequences of his hypothesis of equivalence turned out to be incompatible with Newton's law according to which the action of gravity varies inversely as the square of the distance. Einstein concluded that in the very proximity of the attracting body, that is, in a very strong field of "gravity," there must be some departure from the Newtonian law. His whole argument is beyond the scope of this article, so I shall restrict myself to a few words on the subject, words which, I admit, can-



Derivation of the formula for deflection of light passing the sun. ϕ varies from point to point, the "force" always being directed to the center of the sun. Newton's law of gravitation and the law of deflection in a gravitational field are combined.

not give complete satisfaction to the reader, but which will suffice for our further purposes. In a perfunctory way, then, Einstein's idea is as follows:

The path traversed by a mass following its inertia or moving in a field of gravitation must be described according to Einstein in a purely geometrical (not a dynamical) way. In the close proximity of a gravitating mass (for instance, the sun), space has such geometrical properties that no curves exist which have all the characteristics assigned to straight lines in our traditional Euclidean geometry. Therefore, no rectilinear motion in the traditional sense is even geometrically possible. The curve which a mass traverses by its own inertia or in a field of gravitation is rather "as rectilinear as possible." In the same way, there are on the surface of the earth, speaking precisely, no straight lines; those we observe are as straight as possible.

These straight-as-possible curves are, in a weak field of gravitation, identical with the orbits of the planets derived from Newton's law of attraction, but in the close proximity of large "attracting" masses, the field of gravitation becomes strong; this accounts for a change in a geometrical property of space which is called, in modern geometry, curvature of space. Newton's law of the inverse square of the distance loses its validity and has to be replaced by a different law of attraction. Pursuing this argument mathematically to a finish, Einstein finds a second deflection of light rays is produced in addition to and exactly equal to the first deflection. There results, then, a total deflection of $1''.75$, or, very roughly, two seconds of arc.

Still speaking perfunctorily, one may say that the "weight of light" produces a deflection of one second, and the "curvature of space," a deflection of another second. If the observed deflection is zero, then Einstein is entirely wrong—light does not behave like a falling body nor does it follow the principle of equivalence. If the deflection is nearly one second, light would have "weight" but space would not be curved, and even in the sun's proximity "gravitation" would follow the inverse square law. If, however, the observed deflection is nearly two seconds, Einstein's theory would be confirmed to its whole extent.

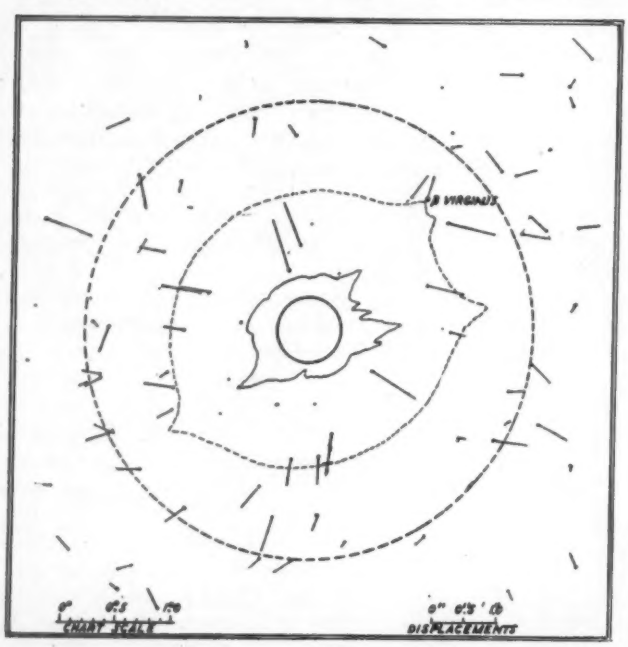
7. The Confirmation

IN its issue of November 7, 1919, the London *Times* carried the headlines: "Revolution in Science. Newtonian Ideas Overthrown." The other headlines of that day, first anniversary of the false armistice in World War I, were, incidentally: "The glorious dead. All trains in the country stop. Red advance against Youdenits. Berlin general strike of the Spartacists collapses."

A joint meeting of the Royal Society and the Royal Astronomical Society was held in London, the subject under consideration being the results of the observations obtained at the solar eclipse on May 29, 1919. The results of the two expeditions sent out by the Joint Permanent Eclipse Committee were announced. Both expeditions were successful, in spite of the cloudy weather. A few photographs were obtained from which the deflection at the sun's limb was found to be $1''.64$.

Sir Frank Dyson, the Astronomer Royal, convinced the meeting that the results were definite and conclusive. Deflection did take place and the measurement showed that the deflection was

(Continued on page 19)



Einstein displacements at the solar eclipse of September 21, 1922, measured by Lick observers for 92 stars. Only displacements of relative weights from 1.0 to 4.0 are plotted. The dashed circle is two degrees in radius; the outlines of the corona are shown, as well as the limit of its faintest traces. The border of the chart is the edge of the plate. At the edge of the sun, the total Einstein deflection should be $1''.75$; at 32′ from the center, $0''.87$; at 48′, $0''.58$, and so on. Chart adapted from Lick Observatory "Bulletin" 346, report of W. W. Campbell and R. Trumpler.

NEWS NOTES

By Dorrit Hoffleit

STELLAR CHLORINE

Chlorine, known to housewives as an effective disinfectant and bleaching agent, has been discovered in the atmospheres of some of the stars. The bleaching process, however, is not very effective there. The stars in which R. F. Sanford, of Mt. Wilson Observatory, recently found the chlorine (in the form of calcium chloride molecules) are among the reddest of the red variable stars, notably U Cygni. This is the first instance of the detection of chlorine in the stars, although ionized chlorine atoms were found in gaseous nebulae by R. H. Stoy at Lick Observatory in 1934.

NOVA CYGNI 1942

Nova Cygni, whose discovery by Zwicky at Palomar was announced in our last month's notes, has suddenly faded—almost as rapidly, it would seem, as it first flared into brilliance in June.

After their first rise to maximum brightness all novae begin to fade, but not all in exactly the same manner. Some fluctuate violently in brightness, while others sink into their ultimate obscurity without any signs of emotion. Not so Nova Cygni. From June to September 25th it fluctuated erratically between magnitudes 7.8 and 10.8. Astronomers, among themselves, ventured predictions on how this nova was going to behave next. Some, having secured good spectra in order to get more clues, are gratified to learn that their guesses were good predictions. The spectrum resembled that of the famous Nova Herculis of 1934. The light curve of Nova Cygni, also, has followed suit, as the spectroscopists anticipated that it would. Between September 25th and October 8th, the star's magnitude dropped to 15.1—only 1/800 as bright as it was on August 11th. How the photographic brightness varied is illustrated below, and the light curve of Nova Herculis is given for comparison.

Will the future course of Nova Cygni follow the pattern of Nova Herculis? We must not be too positive, but amateur variable star observers are urged to keep a watchful eye on the right spot, for the chances are good that the star will suddenly grow bright again. If it does, astronomers are most anxious to know exactly when it starts back up, and at what rate its light increases. All observations on this interesting star will be welcomed at Harvard College Observatory. In order to facilitate your cooperation (if you have a suitable telescope) we show below the details of the star field in the immediate neighborhood of the nova.

Thus far only two stars that behaved like Nova Cygni are known to have achieved naked-eye brilliance. The first was Nova (T) Aurigae, which flared to magnitude 4.2 in December, 1891, and the other was Nova Herculis 1934. This latest nova apparently did not and will not become visible to the naked eye.

A COMET'S IDENTITY

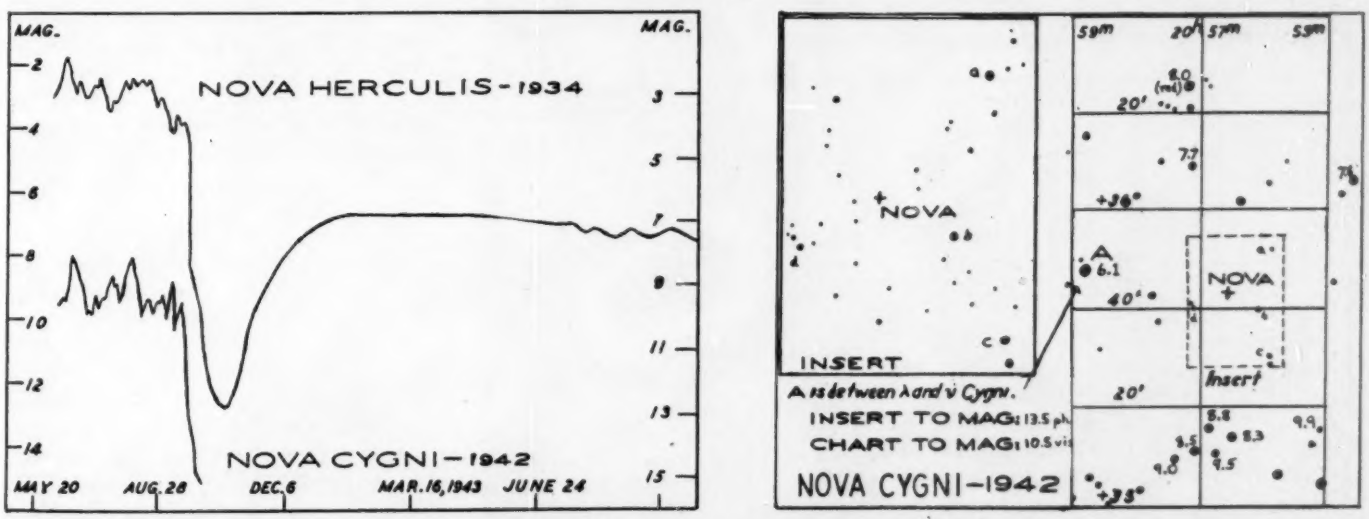
Someone has remarked, "Comet Schwassmann-Wachmann ought to carry a red flag!" so often has it been accidentally announced as a *new* comet. It was first discovered in 1927 by the two German astronomers whose name it bears. Because of its remarkable orbit, which, in unorthodox cometary fashion, is nearly circular and lies entirely between the orbits of Jupiter and Saturn, the comet is seldom out of reach for observation with the larger photographic telescopes. Hence, as Science Service points out, American astronomers have studied it almost continuously for the past 15 years. Sometimes it is as faint as the 18th magnitude, but at times its brightness increases suddenly almost 250-fold. On several such occasions it has been mistaken for a new comet. This happened most recently in October, when the Harvard clearinghouse for astronomical discoveries received word about a new comet from L. Oterma, of Turku Observatory in far-away Finland. G. van Biesbroeck, of Yerkes Observatory, had, however, only a few weeks previously computed the expected position of the comet, searched for the object and found it.

NOT MUCH ON METEORS

This does not happen to be a Leonid year, in spite of the fact that the Leonids seem so closely associated with November. We may, however, introduce another shower which makes a modest appearance nearly every November—the Taurids.

In 1937, astronomers became aware of the importance of this shower by the discovery of 13 Taurid trails on Harvard patrol plates exposed between October 30th and November 10th of that year. This was the largest addition to the meteor photograph collection for any specific shower in any one year that had ever been acquired without special effort.

Dr. F. L. Whipple subsequently discovered much about the shower. Associated with periodic Comet Encke, these meteors revolve in only 3 1/3 years, but the swarm is considerably spread around in its orbit, so we cannot expect to see a very spectacular shower.



Although Nova Cygni was of the 15th magnitude early in October, it may increase its brightness shortly, as shown by a comparison of its light curve with that of Nova Herculis (left). The curve was drawn from magnitudes measured on Harvard pre-discovery plates by Mrs. J. Ashbrook and Mrs. N. Nail. Amateurs are urged to familiarize themselves with the region on the chart at the right, and to watch for a possible rise in brightness of the nova. Limit of magnitude is about 10.5 visual; but that of the insert (compare stars marked a, b, c, d) is about 13.5 photographic. The star A is midway between λ and ν Cygni.

A. A. V. S. O. Fall Meeting

By Percy W. Witherell

THE enthusiasm of members of the American Association of Variable Star Observers was exemplified by the great interest in the papers presented at the annual meeting at Harvard College Observatory on October 9-10, 1942. In spite of the difficulties of transportation and the large percentage of members who are engaged in war work, a goodly number were present from New England and neighboring states.

On Friday evening, the Association was the guest of the Bond Astronomical Club at the observatory and enjoyed a talk on "Astronomy and the Emotional Life of Man," by Lt.-Comdr. E. S. Rademacher, M.D., a member of the New Haven A.A.S. He is a psychiatrist of great experience and discernment, with the ability to present clearly a difficult subject to a lay audience. The fact that the lecturer had little opportunity to enjoy the refreshments of the Bond Club because of the wall of questioners surrounding him after his lecture showed the great interest in his subject.

The Saturday morning session began with a business meeting, at which the most important report submitted was from the Pickering Memorial astronomer and recorder, Leon Campbell. He reported the reception for the year of 33,090 observations from 90 observers. The largest number (4,206) was from Cyrus Fernald, who maintained his leading position of last year. The most efficient members averaged 20 observations per hour. The recorder now has 880,000 observations on hand, accumulated during the past 31 years.

The previous office holders were reelected: Dr. Dirk Brouwer, president; Roy A. Seely and E. A. Halbach, vice-presidents; Mr. Campbell, recorder; David W. Rosebrugh, secretary; P. W. Witherell, treasurer.

The president announced that the Council had voted a Merit Award to D. F. Brocchi, of Seattle, Wash., for his valuable services to the society. This is the sixth such award made by the A.A.V.S.O.; previous recipients have been Rev. T. C. H. Bouton, E. H. Jones, W. T. Olcott, L. C. Peltier, and D. B. Pickering.

Dr. S. Gaposchkin reported on the brightest star known, S Doradus, which is located in the Small Magellanic Cloud. It is a variable star 600,000 times brighter than the sun, a luminosity exceeded only by supernovae for brief periods. Dr. Gaposchkin believes it to be composed of two enormous stars which eclipse each other at regular intervals as they revolve around each other once every 40 years. The diameter of each star is about equal to that of the orbit of Saturn, 1,800 million miles, so they are exceeded in size by only a few other stars.

Dr. Donald H. Menzel exhibited photographs of prominences of the sun and their spectra taken with the Harvard coronagraph at Climax, Colo. He stated that amateur astronomers could convert suitable telescopes into "prominence-graphs" by employing the principle of the quartz and polaroid monochromator invented by John W. Evans, of Chabot Observatory. Dr. Menzel asked for a continual watch on changes in the sun, including variations in the granulations on its surface. He said an A.A.V.S.O. member, the Rev. William A. Kearons, had done valuable work in procuring daily photographs of sunspots.

Mr. Rosebrugh, formerly always a refractor user, demonstrated the convenience of a small, richest-field reflector with which he makes variable star observations. He had added a finder, much to the dismay of Mr. Seely, constructor of the telescope in question.

A paper from the Cousins brothers, of South Africa, on S Muscae, a Cepheid variable with a period of 9 2/3 days, was read.

Joseph Ashbrook gave a paper on Nova Cygni, which was discovered on November 17th by Dr. Fritz Zwicky, at Mt. Palomar. Mr. Ashbrook showed the similarity of the light curve to that of Nova Herculis of 1934 (see "News Notes," this issue) and suggested that although the star's brightness may drop well below the present 15th magnitude, it may later rise to a point considerably brighter, and he urged that amateurs with fairly large telescopes watch the star field carefully.

The possibility of timing daylight occultations on the bright limb of the moon with amateur instruments of 9-inch aperture or better was discussed by J. J. Neale, of the New Haven A.A.S. The moon's disk appears paled in the sunlit sky, and Mr. Neale reported that Aldebaran, at a recent occultation, was bright enough by contrast to be easy to time, at least when observed through the 9-inch Reed telescope at Yale Observatory.

Herbert M. Harris, of South Portland, Me., showed Kodachrome pictures of his observatory. The members were interested in his telescope drive by an electric motor of variable speed.

After a delightful luncheon as the guests of Dr. and Mrs. Harlow Shapley, the out-of-town members attended an observatory colloquium on variable stars. Mr. Campbell gave a scholarly discussion on the results of his statistical interpretation of 750,000 observations of 250 long-period variables. He had determined 12,000 maxima and minima from 450,000 observations during the last 20 years.

Dr. Cecilia Payne-Gaposchkin gave an elaborate paper on her work with Miss Virginia Brenton, in combination with the Milton Bureau, on RV Tauri-type variable stars. Thirteen of these unusual stars were known in 1927; now there are 29 of them. They are characterized by alternating deep and shallow minima which occasionally change places. Dr. Gaposchkin told her audience she believed some of these stars to be "vibrating" according to their fundamental tone whereas others were in their first overtone, after the manner of air in an organ pipe. She amused her audience by demonstrating with several organ pipes how it is possible to make either fundamental or overtone prominent (while suppressing the other) in one and the same pipe. In this way she drew the analogy with some of the RV Tauri stars which appear to change their light curves in a hitherto inexplicable manner. The theory of pulsating stars has been worked out, particularly for Cepheid variables, by Dr. Martin Schwarzschild, of Rutherfurd Observatory.

That a closer watch be kept on Algol, the Demon Star, which is still a mystery after 160 years of study, was urged by Dr. Zdenek Kopal. He thinks it probable that the invisible third component of the eclipsing double star explains some peculiarities of its light changes. There may

(*Continued on page 14*)

The Plane-Spotter's Quandary

Twinkle, twinkle, little star
Up above the earth so far:
How I wonder, as I spot,
Whether you're a star or not!
Glasses to my nose, I ponder
On the point of light out yonder,
Thinking: "That's a moon of Saturn
Making that delightful pattern;
Still, my judgment may be off—
Astral bodies seldom cough.
One more splutter, one more spin,
And, by George, I'll phone you in!"

Now the cloud-formations dim it;
(Honestly, the sky's the limit!)
Silence falls; again I find
I must change my dubious mind
Lest I should report the zodiac
As a flight of Japs from Kodiak,
Thus infringing on the Lick
Observatory's bailiwick.
So I watch the planets climb,
More uncertain all the time,
Till I verge on the delirious—
Quit your clowning! Star, be Sirius!

NORMAN R. JAFFRAY

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Our Nearest Stellar Neighbor

By Bernhard H. Dawson

University Observatory, La Plata, Argentina

ONCE our thoughts pass beyond the confines of the solar system to consider the more distant objects of the universe, our knowledge becomes much less precise. This is unavoidably so, for the distances which separate us from the nearest of the stars are enormously larger than the greatest of the planetary distances. Could we transport ourselves to a star and observe from there, even the planet Jupiter would be invisible, and our entire solar system would reduce itself to a single point, the sun. But just as the nearness of the moon, in comparison to the planets, permits us to see on the moon details of relief much smaller than the least which can be guessed at on Mars, to say nothing of the other planets, so the relative nearness of Alpha Centauri and its being a multiple system have led to a knowledge about it much more complete than what we know about most individual stars.

The constellation Centaurus, the Centaur, of which this system is the most prominent star, is partly visible in mid-northern latitudes low in the south during the summer months, but the two brightest stars are near the southern boundary and cannot now be seen from Europe nor from most of the United States. The entire constellation was, however, visible from Greece in classic times, and the name Κενταυροσ was used by Aratos in the third century B.C. and had probably been in use earlier. The Arabs took over this name, though they often depicted the figure as having the hindquarters of a bear, rather than of a horse. They called the brightest star *Al Rijl al Kentaurus*, the foot of the centaur, from which comes the name *Rigil Kentaurus*, by which it is now known to mariners. The first part of this name is much like Rigel, our name for Beta Orionis, and the derivation is also the same, Rigel being the toe or foot of the hunter, Orion. The stars Alpha and Beta Centauri are also known in the Southern Hemisphere as "pointers," not because they point to the celestial pole as do Beta and Alpha Ursae Majoris, but because they point to the Cross and thus distinguish it, for those who would otherwise confuse them, from the "false cross," a configuration of stars in Vela and Carina.

Alpha Centauri was always rated as of the 1st magnitude, ever since Hipparchus made his classification of stars by brightness. Its light was used as a starting point by Sir John Herschel at the Cape of Good Hope in 1835, in a series of observations which constitute one of the first attempts to measure quantitatively the relative brightness of the stars. In the modern photometric scale, its visual magnitude is 0.06; that is to say, it appears 2 1/3 times as bright as a "standard" 1st-magnitude star and a barely perceptible shade brighter than Vega, the brightest star of the northern sky. Photometric measures of the components of the Centaurus pair by Harvard observers at Arequipa, Peru, assign them magnitudes 0.33 and 1.70. The color of Alpha is distinctly yellow, the fainter star being of deeper hue than the brighter. This is confirmed by the spectroscope, the brighter star being class G0, like the sun and Capella, while the smaller is class K5, like Aldebaran. Their photographic magnitudes are 0.9 and 2.9.

Alpha Centauri was among the first stars known to be double. Its duplicity was discovered by the Jesuit Father Richaud at Pondicherry, India, while observing the comet of 1689, which passed through the southern part of Centaurus just before Christmas of that year. The duplicity was independently found nearly 20 years later by another Jesuit, Father Feuillée, at Lima, Peru, on the night of July 4, 1709. Toward 2 a.m., he was preparing to observe with a telescope of 18 feet focus the emersion of Jupiter's satellite I. Since Jupiter was at the moment covered by clouds, he turned his telescope to Alpha Centauri, which was rather low in the southwest, and found it composed of two stars, noting also that the fainter was the more westerly and that the apparent separation of the disks was about equal to the diameter of the smaller.

The next record is from Lacaille, who observed the components separately at the Cape of Good Hope in 1752. Forming the differences between his places of the two stars, we obtain the first value of their relative position which can be directly expressed in numbers. Beginning in 1822, several other astronomers made similar observations with better instruments, but the really trustworthy observations of the pair as a double star begin with Sir John Herschel's expedition to the Cape in 1834-38. Since then,

The southern constellations, Centaurus, Lupus, and Crux, as they appear in Bayer's famous "Uranometria." Alpha is in the Centaur's left forefoot, and Beta is in his right forefoot, but this star is labeled γ in this drawing. The star labeled β is now called δ.

practically every observer of southern double stars has measured Alpha Centauri, some a few times, others many times each few years over long periods. The one who followed it longest was John Tebbutt, an amateur of Windsor, N.S.W., whose first measures were made in 1880 and his last in 1915.

The relative motion of the components very soon became evident, and attempts to determine the orbit were made as early as 1850, when the micrometric measures covered only a very small part of the ellipse. These manifestly insufficient data were supplemented by interpretations of the older observations, and the character of the resulting orbits depended largely on those interpretations. Even as late as 1886, there was considerable discussion over the relative merits of orbits with periods of 76.2 and 87.4 years, respectively, the difference arising from different interpretations of Father Feuillée's "more westerly." This uncertainty gradually disappeared as the stars approached their greatest separation, which was passed near the turn of the century.

Now, with micrometer measures extending over more than a complete revolution, the orbit is perhaps the most accurately determined of any of the binary stars. Moreover, modern micrometers on large telescopes and especially modern photography with long-focus lenses have so increased the accuracy of measurement and the consequent closeness of the determination, that we can now compute the true position of the companion, for any of those old observations on which the first orbit was based, more accurately than the astronomers of those days could observe it with the instruments then available. The most recent orbit is by W. S. Finsen, of the Union Observatory at Johannesburg. His elements are:

Period of revolution	80.089 years
Time of periastron passage	1875.759
Eccentricity of the true ellipse	0.5208
Position angle of the node	205°.445
Inclination of the orbit plane	79°.233
Node to periastron in orbit	232°.132
Semimajor axis of true orbit	17″.665

The corresponding apparent ellipse is shown in the diagram. From this we see that the companion is now almost exactly north of the principal star. Near 1950 it will pass the northern extremity of the ellipse, and from then on the apparent motion will become increasingly more rapid until the appulse at the beginning of 1958, when the separation will be less than two seconds and the change in angle over 0°.2 *daily*.

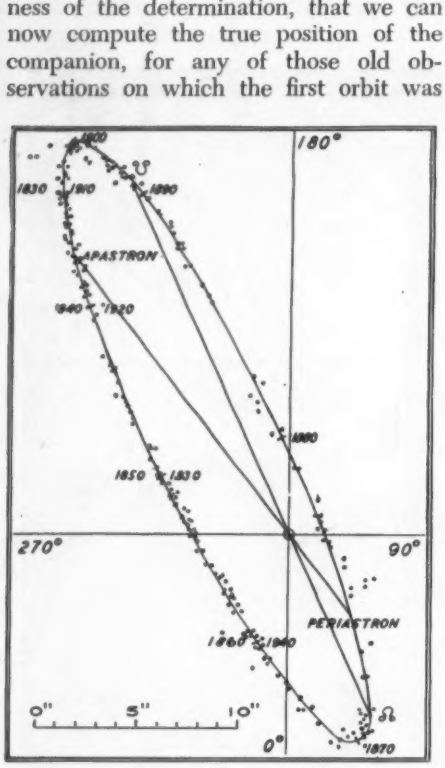
The earliest English observers in the Southern Hemisphere, on comparing their observations of Alpha Centauri with Lacaille's places, noticed that its motion across the sky (proper motion) was one of the largest then known. Henderson was told of this just before leaving the Cape with a quantity of unreduced observations made in 1832 and 1833 and, surmising that the star might well be one of our neighbors in space, he reduced the observations in such a way as to bring to light any evidence of parallax they might contain.

His result was announced in December, 1838, almost simultaneously with those of Bessel on 61 Cygni and of F. G. W. Struve on Vega, the three together constituting our first knowledge of stellar distances and the final and complete vindication of the Copernican concept of the solar system, as against the Ptolemaic concept.[1]

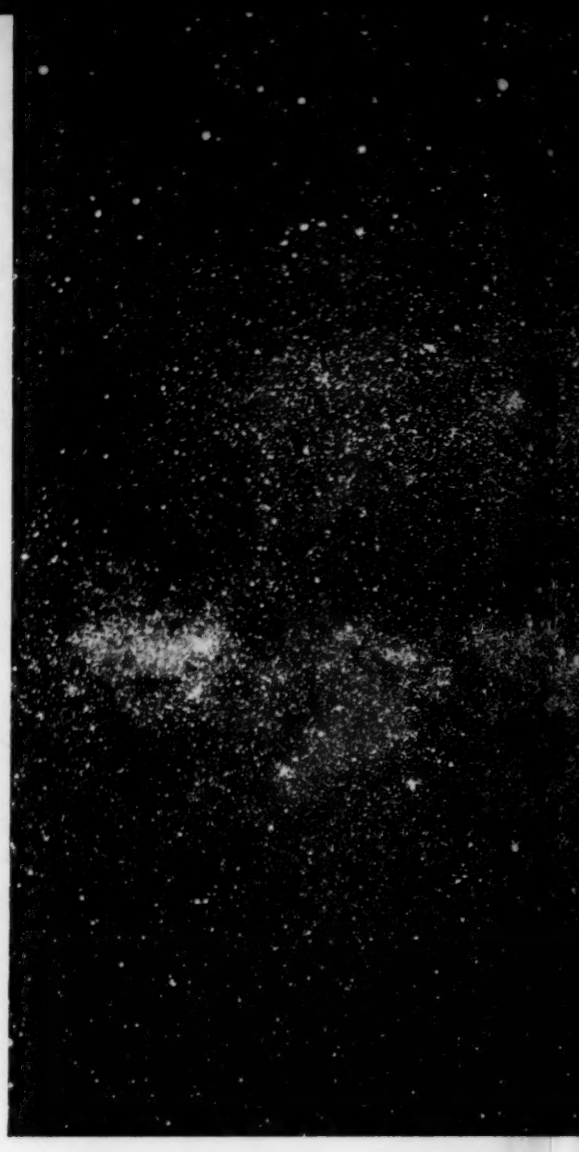
Henderson's result was obtained by reducing each of the meridian observations from apparent to mean place, then taking into account the proper motion and correlating the resulting places with the position of the earth in its orbit. In such a procedure, any *seasonal* variations in atmospheric refraction, the instrument or its constants, are not eliminated. It is consequently not surprising that this first result of 1″.16 was too large by one third its value. It was indeed quite fortunate that he chose this star for his investigation, for it is the only bright star with a parallax[2] large enough to show clearly over and above the unavoidable errors of this class of observations.

Using a heliometer for a careful series of observations from 1881 to 1883, Elkin and Gill measured each component against two pairs of faint comparison stars. The weighted mean of all their series was 0″.75. The most recent, as well as the best, determination was made photographically by H. L. Alden in 1926-28 with the Yale telescope at Johannesburg, obtaining a parallax of 0″.757 with probable error of ±0″.006.

In the first determinations of the proper motion of this pair, each component was considered separately. Since between 1830 and 1835 the stars passed those positions in their orbits which they had occupied at the time of Lacaille's observations, the comparison between his places and the meridian observations of 1822-1840 gave values of the proper motion quite similar for both components and fairly near the true value for the



The orbit of Alpha Centauri (α^2 relative to α^1) for 110 years, after Finsen. Periastron is the point where the stars are nearest to each other; apastron is where they are farthest apart. Individual observations are shown by the small dots.



The Milky Way in Ara, Norma, and Centaurus (north i and β Centauri. Above β to the right (1¾″) is ε Centa Circini. β and γ in Triangulum Australe appear (1¾″ apa is farther south. The star near the top to the left of pius). Proxima is slightly to the right of a point

[1] "The Double Star 61 Cygni," *Sky and Telescope*, January, 1942; "The Poulkovo Observatory," February, 1942.

[2] *Parallax:* the angle subtended at the star by the radius of the earth's orbit. It is inversely proportional to the star's distance.

rus (north is at the top). The two bright stars are α (left) is ε Centauri, and below α and to the right (7/8°) is α r (1 3/8° apart) below the Milky Way. α in this constellation the left of center is ζ in Lupus (which is south of Scor- of a point halfway between α Centauri and α Circini.

center of gravity of the system. Later, there was a marked difference between the apparent motions, owing to the progressive change of relative position as the two stars revolved around their common center of gravity.

Lewis Boss, in the formation of his *Preliminary General Catalogue*, using all positions then available and an orbit by Roberts (one of the first people to attack the composite problem of Alpha Centauri's orbit and proper motion), found a ratio of the masses of the components of 542 to 458 and a proper motion 3″.682 toward 281°.4. More recently, Benjamin Boss, in the formation of the Albany *General Catalogue*, using Finsen's orbit, finds a mass ratio of 554 to 446 and a proper motion which, reduced to 1900, is 3″.674 toward 281°.4.

A trigonometric determination of the parallax of a star yields also a value of its proper motion relative to the comparison stars. In the case of a binary like Alpha Centauri, the values are the apparent motions of the components at the time; these we may either reduce to the proper motion of the center of gravity by using a mass ratio otherwise determined, or else combine with a known proper motion to deduce a value of the mass ratio. In Alden's determination of the parallax, the relative motions, compared with Lewis Boss' values of the motion of the center, duly reduced, gave the value 0.86 as the mass of the companion in terms of the mass of the principal star. This corresponds to the ratio of 538 to 462 in the form used above. From all this it is evident that, although the brighter star is more massive than the companion, the mass difference is small in comparison with the difference in brightness.

The first determination of the motion in the line of sight (radial velocity) of Alpha Centauri was made early in 1904 by W. H. Wright, at the D. O. Mills station of the Lick Observatory in Santiago de Chile. He found that the pair is approaching us, the brighter star somewhat over five km./sec. more rapidly than the fainter at that time, the average being −22.2 km./sec. Radial velocity observations were also begun at the Cape Observatory later in the same year. In 1918, when some 30 observations were available, Joseph Lunt computed the relative velocities of the components due to their orbital motion, supposing them to have equal masses and using Roberts' visual orbit and the parallax by Gill and Elkin. He obtained the accompanying velocity curves and a mean value of approach of the center of mass of 21.64 km./sec. The later value of the mass ratio would have changed this value but little. He also called attention to the fact that in 1927 the orbital motion would be parallel to the plane of the sky, none of the orbital motion of either component then being toward or away from us. This is shown in the velocity curves at their point of intersection. Consequently, radial velocity observations in 1927 would give directly the true velocity of the center of mass without need of knowing the mass ratio. A later value of −22.1 km./sec. was determined by H. Spencer Jones (now Astronomer Royal) while still H. M. astronomer at the Cape.

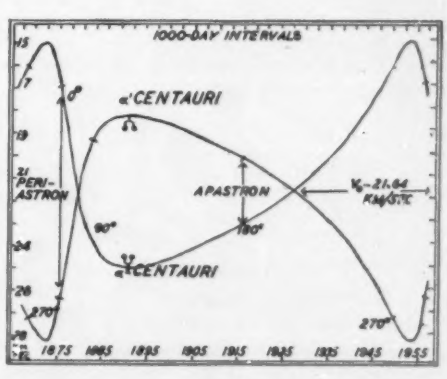
As we see from Lunt's figure, the maximum difference in the radial velocities, at the time of the next passage through the line of nodes (when one star is moving toward us most rapidly relative to the other), will be about 13 km./sec. and will occur between 1950 and 1955. Careful observations at that time, with spectrographs of sufficient dispersion, will make possible accurate determinations of the size of the orbit and a better value of the mass-ratio than can be obtained from meridian observations. In addition, there will result a *value of the parallax fully as accurate as can be determined directly!*

A discussion of this well-known star would not be complete without mention of its possible third component, Proxima Centauri. In the latter part of 1915, during a survey with the blink microscope, R. T. A. Innes discovered a star, photographically of the 13th magnitude and visually of about the 11th, situated 1° 50′ south and 10^m west of Alpha Centauri, with a proper motion similar to that of the bright star, not only in amount but also in direction. This agreement led him to surmise that the distance might also be about the same, so observations were made from May, 1916, to August, 1917, connecting as a double the moving star and another some 30 seconds of arc away. Though the measures were not sufficient for an accurate determination according to modern standards of parallax work, they gave a value close to 4/5 of a second of arc, clearly indicating the nearness of the star and suggesting the name Proxima.

The first photographic determination was made by Voûte at the Cape, giving 0″.755 ± ″.023. A determination by Alden, contemporary with his measures of Alpha, above cited, gave 0″.785 ± ″.005. This places Proxima somewhat nearer us than the bright pair, in a proportion corresponding closely to its proper motion, which is 3″.852 toward 282°.9. Two more recent parallax studies of Proxima, however, one by Voûte at Lembang, Java, the other by Spencer Jones at the Cape, have given 0″.744 and 0″.758. This last value is practically the same as Alden's 0″.757 for Alpha, and would place Proxima at a distance equal to that of Alpha.

Interpreting the results given above, the parallax of 0″.757 determines the distance, which can be expressed as 1.321 parsecs, 4.305 light-years, or 272,500 astronomical units,[3] as may be most convenient, and also tells us that

[3] One astronomical unit equals 93 million miles.



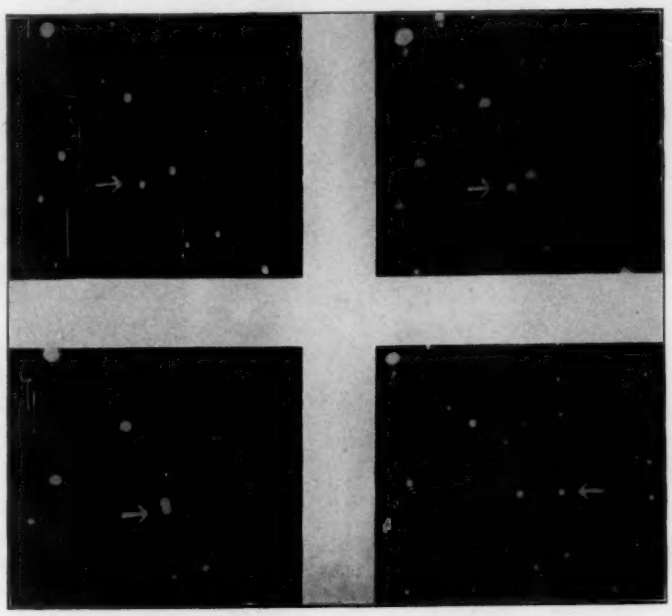
The spectroscopic velocity curves of the components of Alpha Centauri. Relative to the center of gravity of the system, motion toward us is shown by the parts of each curve above the points where they cross. These points give the motion of the center of gravity, which is 21.64 kilometers per second toward the sun. Diagram after Lunt.

the semimajor axis of the orbit is 23.34 astronomical units. This, in turn, combined with the eccentricity, shows that the actual linear distance between the components varies from 11.18 to 35.49 astronomical units, or from a distance somewhat greater than that of Saturn from the sun to nearly that of Pluto. When combined with the period by Kepler's third (harmonic) law, the semimajor axis gives us the sum of the masses of the components as 1.98 times the sun's mass. Of this, 1.09 belongs to the brighter star and 0.89 to the fainter. All of these quantities are, of course, uncertain in the third figure, and the masses even in the second, but they are all approximately correct. Since the sun at that distance would appear of magnitude 0.2 or 0.3, we see that the brighter component, of magnitude 0.33, is closely similar to the sun, not only in spectral type and consequently in surface temperature, but also in mass and luminosity.

The radial velocity shows that the double star is coming nearer by 4.66 astronomical units annually, while the proper motion shows that it also moves 4.85 astronomical units yearly across the line of sight. Thus, on account of the gradually changing perspective with which we view the double-star orbit, it will not appear exactly the same in two successive revolutions. However, this difference is only barely perceptible.

If Proxima Centauri is really at the same distance from us as Alpha, its proper motion would appear to necessitate a hyperbolic orbit between them, so that Proxima would not appear to be a companion of the double star system. Alden's value of the parallax, on the other hand, while indicating a larger distance between Alpha and Proxima—some 14,000 astronomical units—gives space velocities much more nearly alike and leaves open the possibility that Proxima pursues an elliptical orbit around the pair. Even then, the period would be on the order of a million years, unless Proxima be much more massive than its low luminosity (only 1/20,000 of the sun's) would lead us to expect.

We are therefore not quite sure that Proxima is really part of the system, though that seems probable; it is in any case self-luminous, though faint. On the other hand, even as our sister planets would be invisible to a hypothetical observer on Alpha Centauri, so also any similar planets there would be invisible to us. If there be such, the perturbations of their orbits must be enormous and it would seem probable that the amounts of radiation they receive from the two luminaries at different times, and their consequent temperatures, would vary so greatly as to make the existence of life on them unlikely. To go into this matter further with our meager data would be, however, not interpretation but only idle speculation.



The proper motion of Proxima Centauri is shown by arrows indicating its position in 1897, 1901, 1910, and 1925. At its present rate, Proxima moves across the sky a moon's diameter, one half a degree, in about 470 years.

DO YOU KNOW?

By L. J. Lafleur

I. Score five points for each question answered correctly, and one point for each question where you do not attempt to select the answer.

1. Suppose the sun were an ideal radiator. If it cooled until its absolute surface temperature were halved, but its total energy output remained unchanged, its radius would be
   a. quartered c. doubled
   b. halved d. quadrupled
2. Under the above conditions the sun's energy output per unit of surface area would be reduced to
   a. ½ b. ¼ c. ⅛ d. 1/16
3. This is determined by the law of
   a. Roche c. Stefan
   b. Lane d. Lorentz
4. According to Bethe's theory of the carbon cycle, the sun might last another
   a. 30 million years c. 30 trillion
   b. 30 billion d. 30 quadrillion
5. But while the sun is growing older, it will become
   a. hotter c. cooler, then hotter
   b. cooler d. as it is now
6. One of these is not visible during totality in a solar eclipse:
   a. corona c. chromosphere
   b. prominences d. photosphere
7. One of the following instruments is not used to study solar prominences:
   a. coronagraph c. heliometer
   b. spectrohelioscope d. monochromator
8. The Zeeman (magnetic) effect is found in the spectra of
   a. prominences c. photosphere
   b. sunspots d. hydrogen flocculi
9. Reading from the exterior to the interior, the parts of the sun are
   a. photosphere, reversing layer, chromosphere
   b. chromosphere, reversing layer, photosphere
   c. photosphere, chromosphere, reversing layer
   d. reversing layer, chromosphere, photosphere
10. The "butterfly diagram" is concerned with
    a. temperature c. sunspots
    b. flocculi d. prominences

II. The numbers in the first column are significant figures concerning some characteristics of the sun. These are indicated by words in the second column. Pair the numbers with the words, and count five points for each correct pair.

a. 1.4	1. density
b. 11.11	2. diameter
c. 25.33	3. distance
d. 27.64	4. horsepower
e. 70,000	5. mass
f. 330,000	6. rotation
g. 864,000	7. sunspots
h. 1,260,000	8. surface gravity
i. 20,000,000	9. temperature
j. 93,000,000	10. volume

(Answers on page 22)

A.A.V.S.O. FALL MEETING

(Continued from page 10)

even be a fourth member, of the unusual class of stars known as sub-dwarf.

In the evening after an excellent dinner at the Harvard Faculty Club, the society enjoyed the comments of Dr. Shapley on recent events, astronomical and otherwise. His description of the methods and results of the Science Talent Search, recently conducted by Science Service, of which Dr. Shapley is executive committee chairman, showed the great possibilities of helping promising young scientists to obtain the necessary training to make them useful members of the scientific world of the future.

Amateur Astronomers

Some Eclipse Notes from Baltimore

A CLEAR transparent atmosphere, thermometer at 68 degrees, barometer at 30.3 inches, all combined on August 25th to give Baltimore one of its most spectacular eclipses in five years. The color of the moon's disk, as it progressed into the umbra, was very marked and featured by a subtle interplay of colors in the red end of the spectrum, varying from pale yellow through orange and copper to a brick red. At totality the moon appeared as a blackish ball surrounded by an orange-red ring of light. My few notes (partially presented here) may be of interest to other observers for purposes of comparison.

10:15 p.m.–2.5x binoculars: The shadow just touching Copernicus; the eclipsed eastern limb remained relatively bright and was outlined sharply; chocolate tint in the penumbra, whereas July 15, 1935, penumbra was recorded as tinged with yellow.

10:30 p.m. Beautiful copper color growing; Copernicus and Humorum visible in the shadow.

10:30 p.m.–3-inch refractor, 45x: A curious effect is that Oceanus Procellarum is much darker than Nubium, although in full sunlight it is much lighter. Humorum and southern end of Nubium are now densely black. Aristarchus faintly glittering, although in deep shadow; in 1935, 15 minutes after first contact, it was invisible in opera glasses.

10:50 p.m. Rays from Tycho on the west are faintly visible; eastern rays and Tycho itself have vanished.

11:01 p.m. All maria in umbra are indistinguishable in the telescope.

11:10 p.m. 2.5x bin.: Copernicus is visible but not Aristarchus; all maria faintly visible.

11:25 p.m. Copernicus just visible in deepest shadow; Crisium, wholly in shadow, is very dark.

11:50 p.m. Naked eye: Umbra now deep copper red to brick red. North and east limbs brightening.

12:00 p.m. 2.5x bin.: Aristarchus is now faintly visible. There is a grayish light on the west limb; an ashy light, tinged with blue, on the north and east limbs.

JAMES C. BARTLETT, JR.
Baltimore, Md.

LETTER TO THE EDITOR:

My year's subscription to this journal is now soon to expire and I have therefore instructed the Postal authorities to forward to you the sum of 12/6 as before to renew my subscription for one year. You will be glad to know that I have received every issue up to August and find the publication of great interest. I particularly devour the Gleanings for A.T.M.s.

My own telescope (a 10-inch reflector) I made myself, including the mirror, during the height of the blitz. Most of the grinding I did in my workshop, but the polishing and figuring was done indoors in the living room on the dining table, and often to the accompaniment of the drone of aircraft and the noise of gunfire. The testing was carried out in a bedroom which had been rendered uninhabitable owing to a land mine dropping nearby and fetching down the plaster ceiling.

In spite of these conditions, which are hardly those insisted upon by the Rev. W. F. A. Ellison, I succeeded in making quite a good instrument, definition being far better than I had dared to hope for. I am now at work on a 13-inch pyrex disk which I hope to finish sometime.

GEORGE STONEMAN
Sevenoaks, Kent, England
September 7, 1942

ECLIPSE PHOTOGRAPHS

Commendable pictures of the August eclipse have been submitted by several *Sky and Telescope* readers. Robert B. Eccleston, of Binghamton, N. Y., took a series of seven shots which give a good record of its progress. He used a box camera, lens removed, behind the eyepiece on a 35x 1½-inch refractor; Agfa Superpan Supreme film, 1½ seconds exposure throughout.

F. W. Calder, of Glace Bay, Nova Scotia, watched clouds during the early stages, but made seven exposures of the emerging moon. He used a Kodak 2C with a 54 mm. binocular substituted for the regular lens and mounted on a board; Eastman Verichrome, 3 seconds exposure, which proved to be too long, resulting in overexposure and motion of the image.

C. LeBaron Goeller, of Endwell, N. Y., used a double anastigmat lens (6.8) at f/9, with 6½-inch telephoto lens at rear, magnifying about four times; Agfa Process, one second exposure; Agfa process developer which gives no chemical fog. His results were good, but showed some motion of the moon.

CLEVELAND A. S. PROGRAM

Announcement of the series of lectures sponsored by the Cleveland society to be held at the Warner and Swasey Observatory includes, on November 27th, "Comets," Dr. N. T. Bobrovnikoff, of Perkins Observatory, and on January 8th, Leslie C. Peltier, of Delphos, Ohio, speaking on "The Amateur at Work."

A series of public nights at the Warner and Swasey Observatory has been arranged, with observing preceding and following the main lecture. Reservations may be made at the Case School of Applied Science. The dates for November are the 19th and 20th.

AMATEUR ASTRONOMERS ASSOCIATION

New York City

Lectures scheduled for November are:

November 4th, *Calendar Reform –and Why*, Miss Elisabeth Achelis, World Calendar Association.

November 18th, *International Astronomy; Its Past, Present, and Future*, Dr. Bart J. Bok, Harvard College Observatory.

Meetings are held at the American Museum of Natural History, 79th Street and Central Park West, at 8:15 p.m., and are open to the public.

A special eight-weeks course, "Introduction to Celestial Navigation," conducted by Luther G. Schimpf, is announced, beginning the end of November. Inquiries about this and other Association activities may be addressed to the secretary, George V. Plachy, at the Museum. Seven classes in astronomy and related fields are still open for registration.

ORIONID OBSERVING

At the time of going to press, plans were under way for the simultaneous observation, weather permitting, of the Orionid meteor shower on Saturday night, October 17-18th, from 11 p.m. to 2 a.m., by six groups: at Vassar, Mt. Holyoke, and Smith Colleges, Norwalk (N. A. S.), Providence (Skyscrapers), and New Haven (N.H.A.A.S.).

Again for the purpose of observing the same meteors for parallax determination, these groups are also tentatively planning to work on the Saturday night nearest maximum of the Leonids and Geminids. Individuals or groups who wish to join this co-operative arrangement may communicate with J. J. Neale, New Haven A.A.S., Yale Observatory, New Haven, Conn.

WEST COAST NEWS

The October *Bulletin* of the Eastbay Astronomical Association reports that "to carry on" was the expressed purpose of the group of members which met in September, although "we note, with regret, that several of our kindred groups throughout the country are 'suspending for the duration.'"

A new plan for Eastbay meetings, just inaugurated, is to have study and discussion on a definite prearranged topic, with members reviewing beforehand and participating in the discussion, rather than to have the more conventional single speaker for an evening meeting.

For the present, the Chabot Observatory at Oakland, headquarters of the society, is open to visitors each Friday and Saturday from 2 to 9 p.m.

BOOKS AND THE SKY

MAP READING AND AVIGATION

RICHARD M. FIELD AND HARLAN T. STETSON. D. Van Nostrand Co., Inc., 1942. 129 pages. $2.50.

THE birth rate of navigational books has risen so rapidly in recent months that it is difficult to keep track of the new arrivals. Professors Field and Stetson have produced a book that should acquaint the beginner thoroughly with two limited but difficult phases of aerial navigation, map reading from the air and celestial navigation. Whether the conspicuous limitations in subject matter constitute a strength or weakness of this profusely illustrated and well-bound volume is a difficult question.

If, after a careful study of the 61 pages on maps, the air-minded student cannot intelligently read a contour map and visualize the corresponding features on an aerial photograph, then he should look for a job in a factory, preferably one located as close to his home as possible. The reader should also gain from his study some idea of the problems and methods in aerial mapping and some concept of the geological background in topography.

In spite of many large and excellent reproductions for comparative purposes of contour maps, photographs of plastic models, and aerial photographs, the volume contains only one reproduction of an aeronautical chart by the United States Coast and Geodetic Survey, and this without an accompanying table of symbols. The omission was undoubtedly occasioned by the fact that this phase of the problem of aerial navigation is well covered by Government publications, but the omission illustrates the intentionally limited character of the material presented.

Prof. Stetson, similarly, presents celestial aerial navigation very lucidly, but omits a discussion of radio navigation and all but a fragmentary portion of dead reckoning, drift, and navigational instruments. The determination of latitude by a noon sight or by an altitude of Polaris is explained clearly, as are the determinations of lines of position and fixes from bubble-sextant altitudes of the sun, moon, and planets. The reduction of star sights is omitted. Solutions are based solely upon H.O. 214 and the *Air Almanac*. Excerpts from these are presented to permit the solution of 12 practical problems in the Appendix as well as the problems used for illustration.

The beginning student of aerial navigation should find *Map Reading and Avigation* a most valuable supplement to his required list of books. It will replace none of them, but should greatly clarify his understanding of the subject matter covered. The book goes straight to the point in a practical manner, and contains almost no extraneous material. The print is easy to read and the 81 illustrations are all large and well chosen.

FRED L. WHIPPLE
Harvard College Observatory

NEW BOOKS RECEIVED

THE CRUX OF CHRONOLOGY, *Frank Herman Meyer*. 1942, *Bruce, Humphries*. 599 pp. $3.00.
A scholarly discussion of the conflicting systems of chronology in use around the beginning of the Christian era, and the development of a key system for this period. Included is a detailed treatment of the possible astronomical identity of the Star of Bethlehem.

ASTROGRAPHICS, *Frank Debenham*. 1942, *Chemical Publishing*. 118 pp. $2.75.
Subtitled First Steps in Navigation by the Stars—A Primer for the Airman Cadet, this compact book emphasizes the graphic solution of the astronomical triangle and related problems. The stereographic projection is used in the construction of one's own modern astrolabe.

A MATHEMATICS REFRESHER, *A. Hooper*. 1942, *Henry Holt*. 342 pp. $2.50.
A step-by-step book for home reviewing of decimals, algebra, geometry, logs, and other mathematics forgotten or never studied. Exercises and answers to all problems are found at the end of the book. It has appeared on several recent best-seller lists.

MAP READING AND AVIGATION, *R. M. Field and H. T. Stetson*. 1942, *Van Nostrand*. 129 pp. $2.50.
For study by air-minded persons, this well-illustrated book covers in Part I maps and map reading particularly from the point of view of aviators. Part II deals with principles of air navigation by the stars.

MAN AND HIS PHYSICAL WORLD, *Dwight E. Gray*. 1942, *Van Nostrand*. 665 pp. $3.75.
This well-illustrated textbook covers astronomy, chemistry, geology, and physics, and man's relation to these sciences.

YOUTH CONSIDERS THE HEAVENS, *Elsa Marie Meder*. 1942, *Kings Crown Press*. 60 pp. $1.00.
A report of a study made among high school physics students relative to their opinions about man's place in the world in the light of their astronomical information. Of interest to educators, especially in science fields.

INDEX ANNOUNCEMENT

A title page and working index to Volume I of *Sky and Telescope* is in preparation. It will include author, title, subject and topic references, adding considerably to the usefulness of the year's issues. Because of the increased cost of this more elaborate index, a nominal charge must be made for it; price and publication date will be announced next month. ED.

IMPORTANT MACMILLAN REPRINTS

A HISTORY OF SCIENCE
By SIR WILLIAM DAMPIER

"A History of Science" deals with man's attempts from earliest times to understand the nature of the physical world and the mysterious universe around him. The original edition has been revised and a new chapter added dealing with the scientific advances made between 1930 and 1940.

Originally $6.00, now $2.95

PARADE OF THE ANIMAL KINGDOM
By ROBERT HEGNER, *assisted by* JANE Z. HEGNER

From protozoa to dinosaurs and from mollusks to mammoths, one by one the animals pass before you in this book containing more than a thousand representatives, from each group of the animal kingdom. *With 743 illustrations.*

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A complete book on plants written for the general reader. Mr. Hylander classifies and discusses virtually every type of plant now extant in this country—and some exotic ones as well.

Over 300 plant photographs, numerous line drawings.

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Here, reproduced in their full natural colors, are the 435 illustrations of the famous Elephant Folio of Audubon's "Birds," accompanied by concise descriptions of the birds and their range, habitat, feeding and breeding conditions, together with details to help in their identification, by William Vogt, well-known ornithologist.

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WILD FLOWERS
By HOMER D. HOUSE, *State Botanist of New York*

Here are actual color photographs of hundreds of wild flowers, published in a single volume with complete text. The combination of pictures and descriptions makes it possible to identify many wild flowers quickly.

364 color plates, 35 halftones, 20 line drawings.

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BEGINNER'S PAGE

Tides and Their Causes

By Percy W. Witherell

WE have been told since childhood that the attraction of the moon causes the tide to rise. In the preceding article, we made the distinction between the vertical rise and fall of the water, which is the true tide, and the resulting horizontal movements, more accurately described as tidal currents. The vertical-moving periods are called high and low water and the non-moving period, stand; for currents, flow, ebb, and slack are the corresponding terms.

We noted that the greatest effects were due to the shape and slope of the shore and the relative size of the inlet to an interior bay. A drop of 1/10 of an inch of the barometer raises the height of the tide about two inches. An inshore breeze raises the water level, and the normal high water for that day is reached earlier than the predicted time, but the flow continues and the maximum tide of the day is reached at a later hour. The depth of the ocean affects the speed of transmission of the tidal waves. A depth of 100 feet allows a surface velocity of 39 miles per hour, but on oceans of 10,000 feet depth this rate may increase to 388 miles per hour.

When the moon is at perigee, the distance between the moon and the earth being least for the month, the pull of the moon is greater and the height of the tide is increased about 20 per cent over that at apogee.

All these phenomena are clear enough. We think we understand why the water rises on the side of the earth toward the moon, but why does it rise also on the opposite side?

You know that if you were out on a smooth, windless pond in one of two boats connected by a rope in the bows, and you pulled on the rope, the boats, if of equal weight and of similar lines, would approach each other with equal speed, but if one boat were much heavier than the other, the lighter one would move faster. The weight of each boat plus the pull on the rope is offset by an equal force exerted in the opposite direction. In a similar manner the pulls of the moon and other celestial bodies on a particle on the earth's surface are counterbalanced by the gravitational pull toward the center of the earth. This latter pull is popularly spoken of as the weight of an object.

According to Newtonian mechanics, celestial bodies are maintained in their orbits by the combined gravitational pull of all the other objects in the sky, exerted in all directions. As the diameter of the earth is very small in comparison with the distances of all objects except the moon, it may be assumed without material error that all the parts of the earth are influenced as if they were located at its center. It was to prove this that Newton invented his fluxions. The only other important exception is the sun, which, in spite of its distance, has a tide-producing effect because of its great mass. However, although the sun's mass is about 27 million times that of the moon, its tide-raising effect is only 2/5 that of our satellite, because the tide-raising force varies inversely with the cube of the distance.

Let us remember that the gravitational attraction of two bodies varies proportionately to their masses and inversely as the square of their distances. The distance effect is demonstrated very prettily by weighing with spring scales the same object at different points on the earth and showing a variation in its weight corresponding to the distance of the surface from the center, due to the flattening of the earth at the poles. (This fact is used in accurately determining the shape of the earth and the exact latitude of a place.)

The pulls toward the moon and the sun are counterbalanced by forces pulling in the opposite directions at the earth's center. But there is a small difference between the pull of the moon for particles on the surface (and thus nearer to the moon) and the pull for particles at the earth's center. Similarly, the pull for particles on the side of the earth opposite to the moon is slightly less than it is for the center. We can compare these pulls on the basis of distances alone, inasmuch as the masses of earth and moon remain relatively unchanged. Let us call the ratio of the mass of the moon to that of the earth L; its value is nearly 1/80. The average distance of the moon from the center of the earth is 60 times the radius (r) of the earth. Therefore, in the diagram: MA=59r, MC=60r, and MB=61r.

The gravitational pulls of the moon at A, C, and B, are therefore proportional to:

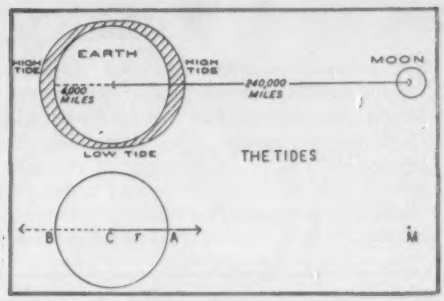
$$\frac{L}{59^2} = \frac{L}{3481} = 0.00002873\ L\ (A)$$

$$\frac{L}{60^2} = \frac{L}{3600} = 0.00002778\ L\ (C)$$

$$\frac{L}{61^2} = \frac{L}{3721} = 0.00002688\ L\ (B)$$

This shows that the outward pull of the moon at A is greater than the opposite gravitational pull of the other celestial bodies at C by about 3.4 per cent (0095 ÷ 2778 = .034); similarly at B, it is less by 3.3 per cent of the pull toward the center by the same force of the heavenly bodies, which thereby keep the center of the earth in equilibrium.

It is seen that this is the differential which causes the tides and that it is a very small part of the forces acting on the earth. An object weighing 4,000 *tons* loses about one pound of its weight when the moon is in its zenith or nadir. At 90 degrees from the moon the weight of such an object is *increased* one half pound. The vertical rise in the open sea due to this differential pull is about two to three feet and in the solid land surface it amounts to nine inches during spring tide.



The upper part shows a theoretical tide, with high water both beneath and opposite the moon. The lower part is explained in the text.

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EDITED BY EARLE B. BROWN

A Simple Filar Micrometer

IN current issues of *Sky and Telescope* have been appearing lists of double stars suitable for observation by amateurs with their own telescopes. In these lists the separations and position angles of the components are given, and these may be roughly checked under suitable observing conditions. However, for more accurate observations and for more enjoyable observations of double stars, the amateur telescopist will do well to possess a filar micrometer, with which he may measure the separations of double stars, position angles, and other differential positions of celestial objects. Anyone with skill at mechanical construction (in which more persons are engaged these days than ever before) can make a micrometer which is quite accurate, and can be used to measure separations down to one half of a second of arc.

The principle of the instrument is that it contains a fixed and a movable reticle wire, and the entire instrument can rotate around the optical axis of the telescope to measure position angle. In the instrument shown in the diagram, the two reticle wires are mounted in rectangular frames. The fixed frame is mounted with screws to the back plate, to which the tube receiving the eyepiece is brazed or soldered. Top and bottom plates are also mounted to the back plate, and each is in the form of an L, with sufficient space for the movable frame to slide between the fixed frame and the shoulder of the L. A simple side plate covers one side.

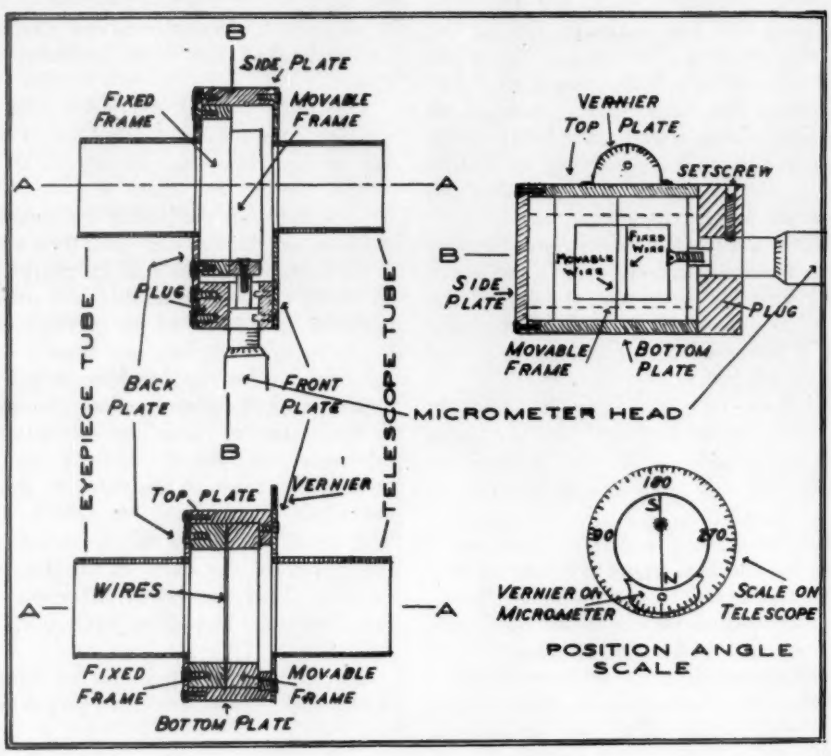
On the other side, the back plate is extended to receive a plug, which is bored to receive the micrometer-head shaft, to be held in place by a setscrew. The micrometer anvil is screwed to one side of the movable frame. The front plate contains the tube which fits the eyepiece adapter of the telescope, and contains, at the top, a vernier scale.

The micrometer head should measure in 10-thousandths of an inch, and is the only ready-made material needed; the other parts can be made from odds and ends of brass or other metal.

The reticle wires should be as fine as possible, of steel wire unless silver or platinum is available. The accuracy of the instrument will depend upon the fineness of the wires. Spider web, of course, is ideal, but it will not stand up to usage. The wires are mounted in shallow grooves in the frames, and are in contact with each other on the sides of the frames in order to bring the two wires as nearly in the same plane as possible. The fixed frame must be mounted so that the wire passes through the optical axis. The screws mounting the frame may be set in slots on the back plate in order to permit fine adjustments. Also, the plane containing the fixed wire and the optical axis should pass through the zero point of the vernier on the front plate. The movable wire must be parallel to the fixed wire, and there must be no looseness of the movable frame in its channels. The micrometer head is adjusted in its hole until the reading is zero when the two wires are coincident in the image plane.

The scale for position angle, as shown in the small diagram, is mounted on the eyepiece adapter of the telescope. The telescope, itself, is mounted so that the plane containing the optical axes of the eyepiece and the telescope (at 90 degrees to each other in a Newtonian reflector) is perpendicular to the declination axis. Then the scale is mounted so that the 0-180-degree line is parallel to the telescope tube, with the zero mark toward the bottom of the tube. If the scale is marked in units of five degrees, then the vernier will contain, on each side of the zero, five equally spaced marks, occupying the distance devoted to 30 degrees on the scale. Thus the instrument will measure to one degree in position angle.

To use the filar micrometer on a double star, proceed as follows: 1. Adjust the telescope and the position angle of the



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RELATIVITY

(Continued from page 8)

in close accord with the theoretical degree predicted by Einstein, opposed to half that degree, the amount that would follow if the field of gravitation had the intensity predicted by Newtonian laws.

Sir Joseph Thomson, president of the Royal Society, called this result "one of the greatest—perhaps the greatest—of achievements in the history of human thought . . . . It is not the discovery of an outlying island but of a whole continent of new scientific ideas. It is the greatest discovery in connection with gravitation since Newton enunciated his principles."

The staggering fact in this discovery was its origin from purely theoretical thinking. It was a triumph of the power of the human mind and the creative power of human imagination. The world was faced by the amazing fact that the universe, sun, light, and stars, behaved exactly in the way they were predicted to behave by Einstein, who based his prediction on his insight into the simplicity of the system of laws governing nature.

This universal feeling was dramatized by the meeting of the learned societies just mentioned. The great philosopher, A. N. Whitehead, who was later professor of philosophy at Harvard, participated in that meeting in London and described his impression in his eloquent language:

"It was my good fortune to be present at the meeting of the Royal Society in London when the Astronomer Royal of England announced that the photographic plates of the famous eclipse, as measured by his colleagues in the Greenwich Observatory, had verified the prediction of Einstein . . . . The whole atmosphere of tense interest was exactly that of the Greek drama: we were the chorus commenting on the decree of destiny as disclosed in the development of a supreme incident. There was dramatic quality in the very staging: the traditional ceremonial, and in the background the picture of Newton to remind us that the greatest of the scientific generalisations was now, after more than two centuries, to receive its first modification. Nor was the personal interest wanting: a great adventure in thought had at length come safe to shore."

However, the confirmation of Einstein's prediction of the deflection of starlight by the gravity of the sun would have passed as a happy coincidence if it had remained the only result of the principle of equivalence.

Einstein himself, in his original paper of 1912, had already drawn conclusions which suggested to astronomers that they venture a different type of observation. Einstein predicted not only an influence of gravity upon the direction of light rays coming from sun and stars, but also an influence upon the frequency or color of this light, and this we shall consider next month.

(To be continued)

This 15-foot Einstein camera was used by the Lick Observatory eclipse expedition to Wallal, Australia, in 1922. The results are shown in the chart on page 8.

A Summary of the Second Installment

AN alternate explanation for the observed phenomena of "gravity" is furnished by Einstein's principle of equivalence. He proposes that a homogeneous field of gravitation is equivalent to acceleration on the part of the reference system itself with respect to another system which is an inertial system. No concept of force is involved in this new kind of gravitation—it is merely the result of the geometry of motion and matter. Einstein retains the word *gravitation*, but it no longer has special and unexplainable significance.

If true, Einstein's new principle should apply to light waves as well as to more tangible matter. The resultant deflection of a beam of light in a gravitational field may be calculated, but it proves to be exceedingly small in the case of phenomena on the surface of the earth. Applied to starlight passing the sun, it is thousands of times larger—specifically, 0.87 seconds of arc for a star appearing just at the sun's edge.

However, the consequences of the principle of equivalence are tied in with the concept of the curvature of space, which is again insignificant in terrestrial cases. But for starlight passing the sun, the "straight line" path is actually curved by another 0″.87, so the entire Einstein "bending of light" is expected to be 1¾ seconds of arc, a sizable and observable quantity.

Confirmation of the complete theory of Einstein resulting from his equivalence principle came with the total eclipse of the sun of May 29, 1919, at which astronomers obtained an observed shift of the position of a star close to the sun amounting to 1″.64, close to the predicted value of 1″.75. Lick Observatory astronomers obtained further and conclusive proof in 1922.

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micrometer so that the fixed wire bisects both stars, with the principal (brighter) star farthest from the vernier end of the wire. Then read the position angle from the scale and vernier. 2. Rotate the instrument through exactly 90 degrees as measured on the scale, in such a direction as to bring the principal star farthest from the micrometer head. 3. Adjust the telescope to bring the star nearest to the fixed wire against this wire, for it will have drifted off when the 90-degree rotation was made. Then adjust the movable wire to bisect the other star and read the separation from the micrometer head in 10-thousandths. A simple conversion table may be made from the knowledge that one second of arc corresponds to 0.0485 10-thousandths for each inch of focal length of the objective.

Some may want to add illumination by the light from a small bulb showing through a hole in the side plate. Another improvement is the addition of a fixed wire perpendicular to the others, so that if the principal star is brought to the center of the cross wires, it will not be necessary to reset the telescope after measuring position angle. But the wires must cross exactly on the optical axis, and this must correspond exactly with the mechanical axis of the adapter tube.

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THE STARRY HEAVENS IN NOVEMBER

Oil and the Golden Fleece—Outmoded Signs of the Zodiac—Locating the Greenwich of the Sky

By Leland S. Copeland

TOWARD the land of the golden fleece thousands of men have been struggling in 1942. Colchis is still a treasure realm, but now the prize is oil, not the aureate skin of Aries.

Long ago, in days that only legends can recall, Jason and 50 heroes of Greece, hankering for high adventure, invaded the country east of the Black Sea. In 1942, Hitler and his Nazi hordes have been battling toward the same region in an effort to seize riches with which to enslave the world. Colchis today is Transcaucasia or Georgia, across which runs one of the pipe lines from Baku, chief Russian oil city.

From Georgia came Stalin and the marrying princes that invaded American society a few years ago.

According to Grecian mythic lore, a king of Thessaly divorced his wife and married again. The first spouse, seeking to save her children from a stepmother's influence, placed them on the back of a ram sent by Mercury. The sturdy animal sped like an airplane toward Colchis, while Phrixos and Helle clung to its golden fleece. As they crossed the Dardanelles, Helle lost her grip and fell to death in the straits, which thereafter bore her name.

Phrixos arrived safely in the Transcaucasian land. After he had sacrificed the ram to Zeus, he presented its shining skin to King Aeëtes. This precious memento, guarded by a dragon, remained in a sacred grove until the Argonauts arrived.

When Jason asked for the ramskin, crafty Aeëtes agreed to yield it, provided the hero could yoke two fire-breathing bulls and would sow the Cadmean dragon's teeth—seed certain to produce a crop of soldiers as merciless as Nazis. Aided by Medea, the king's daughter, Jason survived the ordeals and took the fleece triumphantly back to Greece.

In November at 10 p.m. war time, golden Aries flies high in the southeastern sky, and by December it will have ascended to the meridian. But for a good view of Argo, the starry memorial of Jason's ship, we must wait until February.

Aries, a zodiacal constellation, consists chiefly of the bright Ram's head, α, β, and γ. Gamma is a handsome double—white twins. Lambda, also in the head, is a wide double. To complete the figure we must include three 4th-magnitude stars, forming a bent line halfway between α (Hamal) and the Pleiades.

The so-called first point in Aries is not in Aries; through most of the Christian centuries it has been in Pisces. It is the vernal equinox, Greenwich of the sky.

About March 21st, "Sun enters sign of Aries; equinox," says the *Nautical Almanac*. To understand this cryptic language, we must go back to the ancients. They divided the zodiac into 12 signs, each 30 degrees long and named after the constellation it enclosed. But the wobbling of the earth (precession) causes the vernal equinox to creep westward. So, after two milleniums, each sign is now one constellation farther west.

Signs and symbols of the zodiac help astrologers to impress the unthinking public. Should not these kindergarten materials be dropped from astronomical publications, so that the distinction between false and true would be more obvious?

If the alphabet had slipped like the components of the zodiac, we should spell *cab* as *bza*. And intelligent persons could learn to read *bza* as *cab*, but why should they?

Some astronomers are trying to explain to the public how vastly their science differs from astrology. First, they ought to sweep away those moldy antiques that clutter astronomy and decorate astrology, the zodiacal signs and symbols. Almanacs should read, "Sun reaches vernal equinox," or "Sun crosses celestial equator, northward."

The vernal equinox is in the western Fish, about halfway between ω and a wee parallelogram of dim stars, 27, 29, 30, and 33. After leaving the north celestial pole, the equinoctial colure passes just west of β Cassiopeiae and α and γ Pegasi, then threads through the vernal equinox and descends between Cetus and the water from the Aquarian jar.

Toward the east, Taurus and Orion appear, still engaged in their immemorial duel. They are followed by Auriga and Gemini. Deneb Kaitos, tail star of the Whale, with Andromeda and Cassiopeia, holds the mid-November meridian at 10 p.m. Westward, Lyra, Aquila, and Capricornus are approaching the horizon, and behind them decline the Northern Cross of Cygnus and the Great Square of Pegasus.

THE MOON AND PLANETS IN THE MORNING AND EVENING SKIES

In mid-northern latitudes, the sky appears as at the right at 6:30 a.m. on the 7th of the month, and at 5:30 a.m. on the 23rd. At the left is the sky for 6:30 p.m. on the 7th and for 5:30 p.m. on the 23rd. The moon's position is marked for each five days by symbols which show roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury, *Venus*, and *Mars* are too close to the sun for observation.

Jupiter, in Gemini, will start its retrograde motion on November 12th.

Saturn and *Uranus*, in Taurus, will continue their retrograde movements. Saturn and Aldebaran make an interesting pair of noticeably differing color.

Neptune is in Virgo.

SEEIN' THINGS AT NIGHT

THE Great Square of Pegasus, according to the editor of *Sky and Telescope*, "makes a wonderful baseball diamond, with α as home plate, β as first base, and ο of Andromeda as the flagpole in right field. The flagpole in left field is η in Pisces. The climax comes when a fly ball is hit from home plate across second base (Alpheratz) to the center fielder, fast-moving M31. Even if the ball could move with the speed of light, you would get tired waiting for the center fielder to catch it, for that would take 680,000 years."

This whimsical picture suggests that we all can follow the lead of the old Sumerian priests. They made themselves at home in the sky by imagining there likenesses of everyday objects. Some of their "similes" are far-fetched, but all are aids to memory. It is not too late for us to dream, unofficially of course. Thus either in Cygnus or in Aquila we can see a starry airplane.

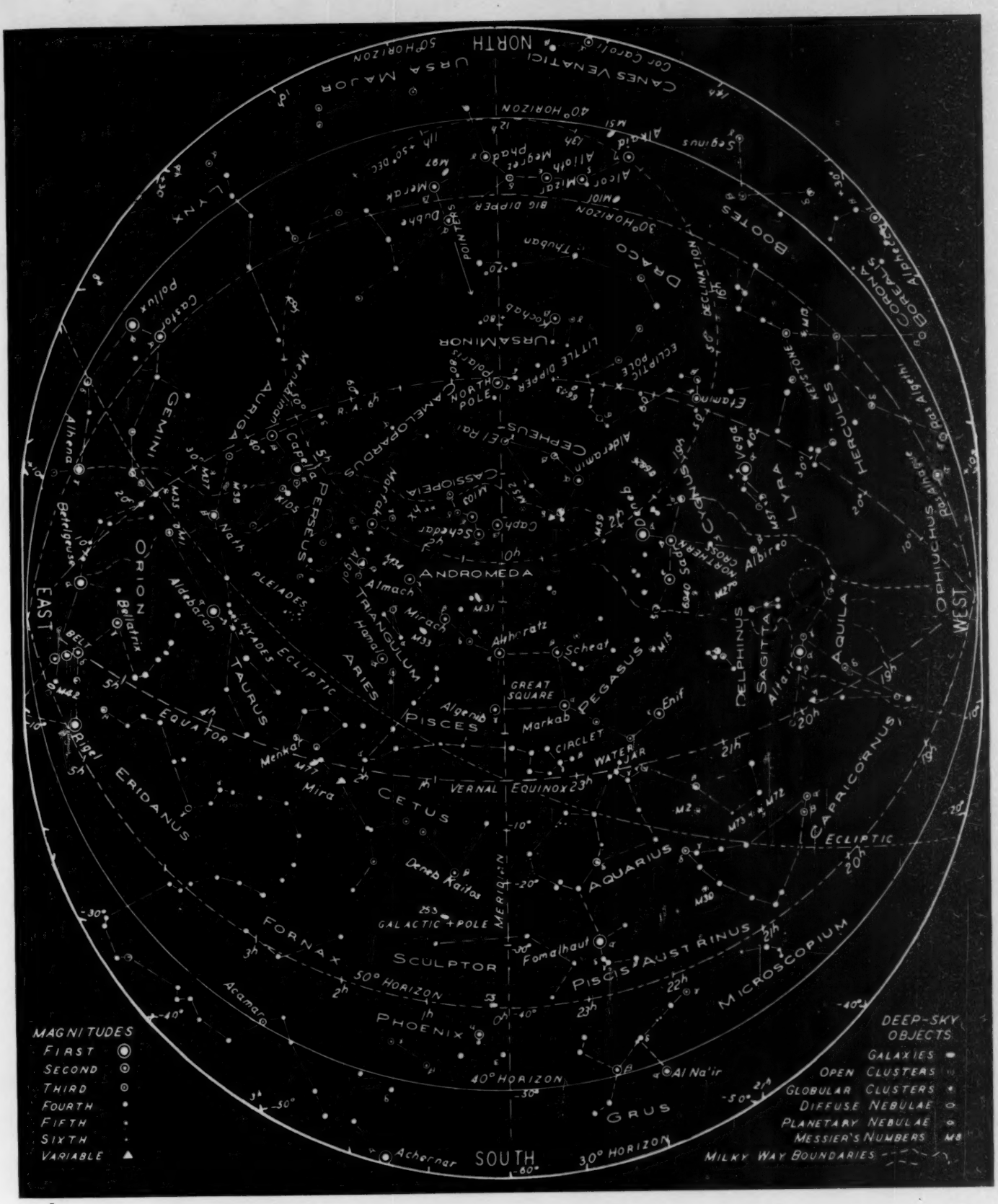
Sir James Jeans thinks that Thuban, pole star of 2500 B.C., is like a bun held in front of the Little Bear's nose. The Dragon's head has four stars, which, says Dr. Lewis C. Carson, Santa Barbara amateur, make an arrowhead pointing toward Vega.

Odd ideas like these help amateurs—and even professionals when they have time to look at the surface of the sky.

DEEP-SKY WONDERS

UNDER this head will be presented each month about a dozen marvels, recommended for observation through amateur telescopes. Those who look for them will take a profitable and enjoyable sight-seeing tour through the night sky.

Please remember that right ascension and



declination positions are as simple to understand as those of longitude and latitude on earth, of which they are counterparts. Also, it is not necessary to have circles on your telescope; locate the wonders on sky charts equipped with hour and degree lines. This month let us look at:

Three clusters: hχ, in Perseus, $2^h\ 12^m$, $+56°\ 41'$; N.G.C. 6940, Vulpecula, $20^h\ 30.4^m$, $+27°\ 58'$; M52, Cassiopeia, $23^h\ 19.8^m$, $+61°\ 03'$.

Three globulars: M15, Pegasus, $21^h\ 27.4^m$, $+11°\ 56'$; M2, Aquarius, $21^h\ 30.6^m$, $-1°\ 04'$; M30, Capricornus, $21^h\ 37.3^m$, $-23°\ 26'$.

Three galaxies: N.G.C. 55, Sculptor, $0^h\ 12.5^m$, $-39°\ 30'$; N.G.C. 253, Sculptor, $0^h\ 45.1^m$, $-25°\ 34'$; M33, Triangulum, $1^h\ 31^m$, $+30°\ 24'$. (See back-cover photo.)

Three planetaries: M57 (Ring), Lyra, $18^h\ 52^m$, $+32°\ 57'$; N.G.C. 6826, Cygnus, $19°\ 43^m$, $+50°\ 23'$; M27 (Dumbbell), Vulpecula, $19^h\ 57^m$, $+22°\ 34'$.

Large amateur telescopes often are needed for finding galaxies and planetaries.

THE STARS FOR NOVEMBER

as seen from latitudes 30° to 50° north, at 10 p.m. and 9 p.m. on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "NORTH" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.

OBSERVER'S PAGE

All times mentioned on the Observer's Page are Eastern war time.

The Poles in the Sky

WE are all familiar with the location of Polaris, the North Star, and know it to be slightly more than one degree south of the true point in the sky occupying the extension of the earth's polar axis. For the amateur who wishes to set a portable equatorial telescope mounting with some degree of accuracy, it is necessary to know the approximate location of this true north point. It may be found by drawing an imaginary line from Polaris to Mizar, the middle star in the handle of the Big Dipper; and on this line at a distance equal to twice the width of the moon from Polaris will be found the required position. As the Dipper revolves around the north pole, Polaris does too, describing a small circle, two degrees in diameter, every 24 hours. The center of this circle is the true north pole.

This circle can be easily observed, but it is first necessary to establish your local meridian by means of two objects that are exactly north and south of each other—such as two carefully plumbed posts, so set that their shadows form a continuous line at 1 p.m. (war time) on any of the four days noted in my article in the September issue. At my tropical island home I found the edge of a brick wall and the left-hand side of a porch post made a line that was exactly the local meridian. If we sight along such a line, it is easy to observe the transit of Polaris and watch its slow movement toward the west.

At about the end of December, Polaris will be at the top of the circle, or at upper culmination, around 7:00 p.m., and will reach the west side, or western elongation, in one minute less than six hours. A few observations of this movement will help to form a mental picture of the length of the radius of the circle, which is so necessary for a quick orientation of a portable equatorial mounting.

This method of finding approximate true north is helpful in the navigation of small boats not equipped with a gyrocompass, and obviates the necessity of knowing the variation of the magnetic compass in different latitudes. However, if more exact navigation is required, the *American Ephemeris* publishes tables that give exact data on the motions and positions of Polaris, whereby from the sighting of the star at any hour on any night, a navigator may determine true north. The smaller *Nautical Almanac* also contains this information.

Our south pole is not marked by so bright a nearby star as is the north, but there are two stars just visible to the unaided eye that are close to the pole and are frequently used in navigation. These are Sigma Octantis, magnitude 5.5, and Chi Octantis, magnitude 5.2. Sigma is 50 minutes from the pole, a little closer than Polaris is to the north pole, and Chi is 90 minutes farther away. In binoculars, they are quite bright, and stand out in a field that has very few stars and none brighter.

For the epoch of 1942, a line through these two stars will miss the south pole by 31 minutes in the direction of the Small Magellanic Cloud. This latter distance, however, is constantly changing, and there is an appreciable difference every four or five years. Almost exactly 100 years ago, the two stars had the same right ascension, $17^h\ 20^m$, so a line through them passed through the pole. At that time, Sigma was nearer to the pole by about 10 minutes.

In the latitude of Cape Town, South Africa, Sydney, Australia, or Auckland, New Zealand, the Southern Cross and the Small Magellanic Cloud are circumpolar; they never go below the horizon. (A celestial object is circumpolar if its declination plus the observer's latitude equals more than 90°.) The Southern Cross is 30° from the pole, and the near edge of the Cloud, 15°, but they are on opposite sides, making them 45° apart with the pole two thirds of the distance from the Cross between them. On the 1st of May, the center of the Cross makes the upper transit of the meridian at 10 p.m., as the western edge of the Cloud is making the lower transit. If we make our observation at that time, preferably with binoculars, the two stars, Sigma and Chi, can readily be seen slightly to the left of our vertical line and two thirds of the distance below the Cross. As viewed in this position, the true pole will be found slightly more than half a degree above the intersection of our vertical line with a line through the two stars.

There are other poles in the sky. The pole of the sun's axis of rotation is at R.A. $18^h\ 44^m$, Dec. +64°, or very nearly halfway between Vega and Polaris and in the constellation Draco. Not far away and also in Draco is the north pole of the ecliptic, R.A. 18^h, Dec. +67°.5. The south pole of the ecliptic, R.A. 6^h, Dec. −67°.5, is on the eastern edge of the Large Magellanic Cloud.

Our great Milky Way galaxy also has north and south celestial poles, located respectively at R.A. $12^h\ 40^m$, Dec. +28°, in Coma Berenices, and R.A. $0^h\ 40^m$, Dec. −28°, in Sculptor. The center of the galaxy is at R.A. $17^h\ 30^m$, Dec. −30°, on the borderline between Ophiuchus and Scorpius. (See "In Focus," September *Sky and Telescope*.) It is near the clusters M6 and M7, so brilliant in low-powered telescopes, and in one of the rifts of the Milky Way caused by great accumulations of cosmic dust through which the light from the stars beyond cannot penetrate.

MINIMA OF ALGOL

November 16, 3:55 a.m.; 19, 0:44 a.m.; 21, 9:33 p.m.; 24, 6:22 p.m.

By Jesse A. Fitzpatrick

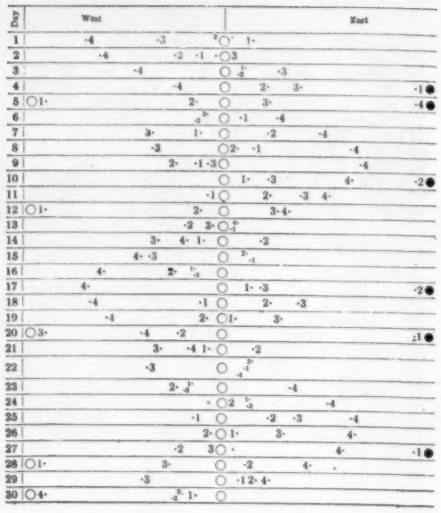
JUPITER'S SATELLITES

On November 15th, the four principal moons will be on the west side of the planet.

On the 5th, between 2:05 a.m. and 4:02 a.m., only moons *II* and *III* will be visible; *I* is in transit, and *IV* in occultation.

November 20th, between 2:58 and 5:08 in the morning, only moons *II* and *IV* will be visible; *III* being in transit and *I* in occultation.

Jupiter's four bright moons have the positions shown below at 3:00 a.m., E.W.T. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. From the **American Ephemeris.**



PHASES OF THE MOON

Last quarter	November 1,	2:18 a.m.
New moon	November 8,	11:19 a.m.
First quarter	November 15,	2:56 a.m.
Full moon	November 22,	4:24 p.m.
Last quarter	November 30,	9:37 p.m.

THE LEONIDS

The Leonid meteors due this month will reach maximum about the 16th. Mediocre displays in recent years do not give hope for any particularly brilliant shower this year.

Answers to DO YOU KNOW?

(Questions on page 14)

I. 1, d; 2, d; 3, c; 4, b; 5, a; 6, d; 7, c; 8, b; 9, b; 10, c.

II. a, 1; b, 7; c, 6; d, 8; e, 4; f, 5; g, 2; h, 10; i, 9; j, 3.

OCCULTATIONS—NOVEMBER, 1942

Local station, lat. +40° 48′.6, long. $4^h\ 55.8^m$ west.

Date	*Mag.*	*Name*	*Immersion*	*P.**	*Emersion*	*P.**
Nov. 1	6.3	54 Cancri	4:40.2 a.m.	104°	6:09.6 a.m.	282°
3	5.9	45 Leonis	3:42.2 a.m.	40°	4:13.1 a.m.	350°
17	5.2	29 Piscium	7:00.7 p.m.	36°	8:13.4 p.m.	271°
17	6.3	4 Ceti	11:03.9 p.m.	98°	0:06.1 a.m. (18)	209°
17	6.3	5 Ceti	11:23.2 p.m.	89°	0:30.4 a.m. (18)	219°
19	4.7	ν Piscium	7:36.4 p.m.	54°	8:53.5 p.m.	253°
23	5.7	318 B Tauri	—	—	7:52.0 p.m.	260°

* P is the position angle of the point of contact on the moon's disk measured eastward from the north point.

HERE AND THERE WITH AMATEURS

This is not intended as a complete list of societies, but rather to serve as a guide for persons near these centers, and to provide information for traveling amateurs who may wish to visit other groups.

City	*Organization*	*Date*	*P.M.*	*Season*	*Meeting Place*	*Communicate with*
BOSTON	BOND AST. CLUB	1st Thu.	8:15	Oct.-June	Harvard Obs.	Homer D. Ricker, Harvard Observatory
"	A.T.M.S OF BOSTON	2nd Thu.	8:15	Sept.-June	Harvard Obs.	F. I. Noyes, 340 Warren St., Brockton, Mass.
BROOKLYN, N.Y.	ASTR. DEPT., B'KLYN INST.	Rd. Table 3rd Thu.	8:00	Oct.-April	Brooklyn Inst.	William Henry, 154 Nassau St., N.Y.C., *BA.* 7-9473
BUFFALO	A.T.M.S & OBSERVERS	1st, 3rd Fri.	8:00	Oct.-June	Mus. of Science	J. J. Davis, Museum of Science
CHATTANOOGA	BARNARD A. S.	4th Fri.	7:30	All year	Chattanooga Obs.	C. T. Jones, 1220 James Bldg., *CHat.* 6-8341
CHICAGO	BURNHAM A. S.	2nd, 4th Tue.	8:00	Sept.-June	Congress Hotel	Wm. Callum, 1435 Winona Ave.
CINCINNATI	CIN. A.A.	2nd Fri.	8:00	Sept.-June	Cincinnati Obs.	Dan McCarthy, 1622 DeSales Lane
CLEVELAND	CLEVELAND A. S.	Fri.	8:00	Sept.-June	Warner & Swasey Obs.	Mrs. Royce Parkin, The Cleveland Club
DAYTONA BEACH	D. B. STARGAZERS	Alt. Mon.	8:00	Nov.-June	500 S. Ridgewood Ave.	Rolland E. Stevens, 500 S. Ridgewood
DETROIT	DETROIT A. S.	2nd Sun.	3:00	Sept.-June	Wayne U., Rm. 187	E. R. Phelps, Wayne University
"	NORTHWEST A.A.S.	1st, 3rd Tue.	8:00	Sept.-June	Redford High Sch.	A. J. Walrath, 14024 Archdale Ave.
DULUTH, MINN.	DULUTH AST. CLUB	1st, 3rd Sat.	8:00	All year	Darling Obs.	W. S. Telford, 126 N. 33rd Ave. E.
FT. WORTH	TEX. OBSERVERS	No regular meetings				Oscar E. Monnig, 1010 Morningside Dr.
GADSDEN, ALA.	ALA. A.A.	1st Thu.	7:30	All year	Ala. Power Audit.	Brent L. Harrell, 1176 *W* or 55
INDIANAPOLIS	INDIANA A.A.	1st Sun.	2:00	All year	Central Library Audit.	E. W. Johnson, 808 Peoples Bank Bldg.
JOLIET, ILL.	JOLIET A.S.	Alt. Tue.	8:00	Oct.-May	Jol. Mus. & Art Gall'y	Monica L. Price, 403 Second Ave.
LOS ANGELES	L.A.A.S.	2nd Thu.	8:15	.....	2606 W. 8th St.	Charles Ross, 2606 W. 8th St.
LOUISVILLE, KY.	L'VILLE A.S.	3rd Tue.	8:00	Sept.-May	Women's Bldg., Univ. of Louisville	Mary Eberhard, 3-102 Crescent Ct., *Taylor* 4157
MADISON, WIS.	MAD. A.S.	2nd Wed.	8:00	All year	Washburn Obs.	C. M. Huffer, Univ. of Wisconsin
MILWAUKEE	MILW. A.S.	1st Thu.	8:00	Oct.-May	Marquette U., Eng. Col.	E. A. Halbach, *Hopkins* 4748
MOLINE, ILL.	POP. AST. CLUB	2nd Tue.	7:30	All year	Sky Ridge Obs.	Carl H. Gamble, Route 1
NEW HAVEN	NEW HAVEN A.A.S.	4th Sat.	8:00	Sept.-June	Yale Obs.	Milton T. Corbett, 47 Canner St.
NEW YORK	A.A.A.	1st, 3rd Wed.	8:15	Oct.-May	Amer. Mus. Nat. Hist.	G. V. Plachy, Hayden Plan., *EN.* 2-8500
" "	JUNIOR AST. CLUB	Alt. Sat.	8:00	Oct.-May	Amer. Mus. Nat. Hist.	J. B. Rothschild, Hayden Plan., *EN.* 2-8500
NORWALK, CONN.	NORWALK AST. SOC.	Last Fri.	8:00	Sept.-June	Private houses	Mrs. A. Hamilton, 4 Union Pk., 6-4297
OAKLAND, CAL.	EASTBAY A.A.	1st Sat.	8:00	Sept.-June	Chabot Obs.	Miss H. E. Neall, 6557 Whitney St.
PHILADELPHIA	A.A. OF F.I.	3rd Fri.	8:00	All year	The Franklin Inst.	Edwin F. Bailey, *Rit.* 3050
"	RITTENHOUSE A.S.	2nd Fri.	8:00	Oct.-May	The Franklin Inst.	A. C. Schock, *Rit.* 3050
PITTSBURGH	A.A.A. OF P'BURGH	2nd Fri.	8:00	Sept.-June	Buhl Planetarium	Louis E. Bier, 402 Cedarhurst
PONTIAC, MICH.	PONTIAC A.A.A.	2nd Mon.	8:00	All year	Private homes	John Setlow, Jr., 593 S. Paddock St.
PORTLAND, ME.	A.S. OF MAINE	2nd Fri.	8:00	All year	Private homes	H. M. Harris, 27 Victory Ave., S. Portland
PORTLAND, ORE.	AST. STUDY GROUP	1st Mon.	8:00	All year	420-3 Av., Rm. 212	H. J. Carruthers, 427 S. 61 Ave.
PROVIDENCE, R.I.	SKYSCRAPERS	1st Wed.	8:00	All year	Wilson Hall, Brown U.	Ladd Obs., Brown U., *GA.* 1633
READING, PA.	READING-BERKS A.C.	2nd Thu.	8:00	Sept.-June	Albright College	Mrs. F. P. Babb, 2708 Filbert Ave.
RENO, NEV.	A.S. OF NEV.	4th Wed.	....	All year	Univ. of Nevada	G. B. Blair, University of Nevada
ROCHESTER, N.Y.	ROCH. AST. CLUB	Alt. Fri.	8:00	Oct.-May	Eastman Bldg., Univ. of Rochester	M. L. Groff, 400 University Ave.
SAN ANTONIO	SAN ANT. A.A.	3rd Mon.	8:00	All year	Le Villela	R. B. Poage, 807 Hammond Ave.
SCHENECTADY	S'TADY AST. CLUB	3rd Mon.	8:00	All year	Observatory site	C. H. Chapman, 216 Glen Ave., Scotia
SOUTH BEND, IND.	ST. JOSEPH VAL. AST.	Last Tue.	8:00	All year	928 Oak St.	Fannie Mae Chupp, 224 Seebirt Pl.
STAMFORD, CONN.	STAMFORD AST. SOC.	4th Wed.	8:00	Oct.-June	Stamford Museum	Stamford Mus., 300 Main St.
TACOMA, WASH.	TACOMA A.A.	1st Mon.	....	All year	Coll. of Puget Sound	Geo. Croston, *Gar.* 4124
WASHINGTON, D.C.	NAT'L. CAP. A.A.A.	1st Sat.	8:00	Oct.-June	U. S. Nat'l. Museum	Stephen Nagy, 104 C St., N.E., *Linc.* 9487-J
WICHITA, KANS.	WICHITA A.S.	2nd Tue.	8:00	All year	E. High Sch., Rm. 214	S. S. Whitehead, 2322 E. Douglas, 33148
YAKIMA, WASH.	YAK. AM. ASTR'MERS	2nd Tue.	7:30	All year	Y.M.C.A. Audit.	J. L. Thompson, 4 S. 10 Ave., 21455

Sky and Telescope is official publication of many of these societies.

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PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

★ **THE BUHL PLANETARIUM** presents *in November*, MODERN SKY PICTURES—by Cy Hungerford.

In this new and different sky show, the famous cartoonist, Cy Hungerford, turns his unique talent for humorous and trenchant characterization to the heavens, revamping the star pictures of the ancients and presenting them in modern dress. Have you found it difficult to see in the stars of Cetus the figure of a sea-monster? Or a winged horse in the stars of Pegasus, or a queen in the W of Cassiopeia? Has it been easier for you to imagine in the starry heavens other objects more familiar to us in the streamlined world of 1942? Why not, then, transfer the great changes that have taken place below to the heavens above? Certain evidence indicates that the original constellation pictures may have had woven in them some ancient legend—a story immortalized in the stars. In this sky show, we see how the stars can tell us some new story, woven about our modern things and people by one of America's great cartoonists.

★ **THE HAYDEN PLANETARIUM** presents in *November*, SAILING THE SEVEN SEAS.

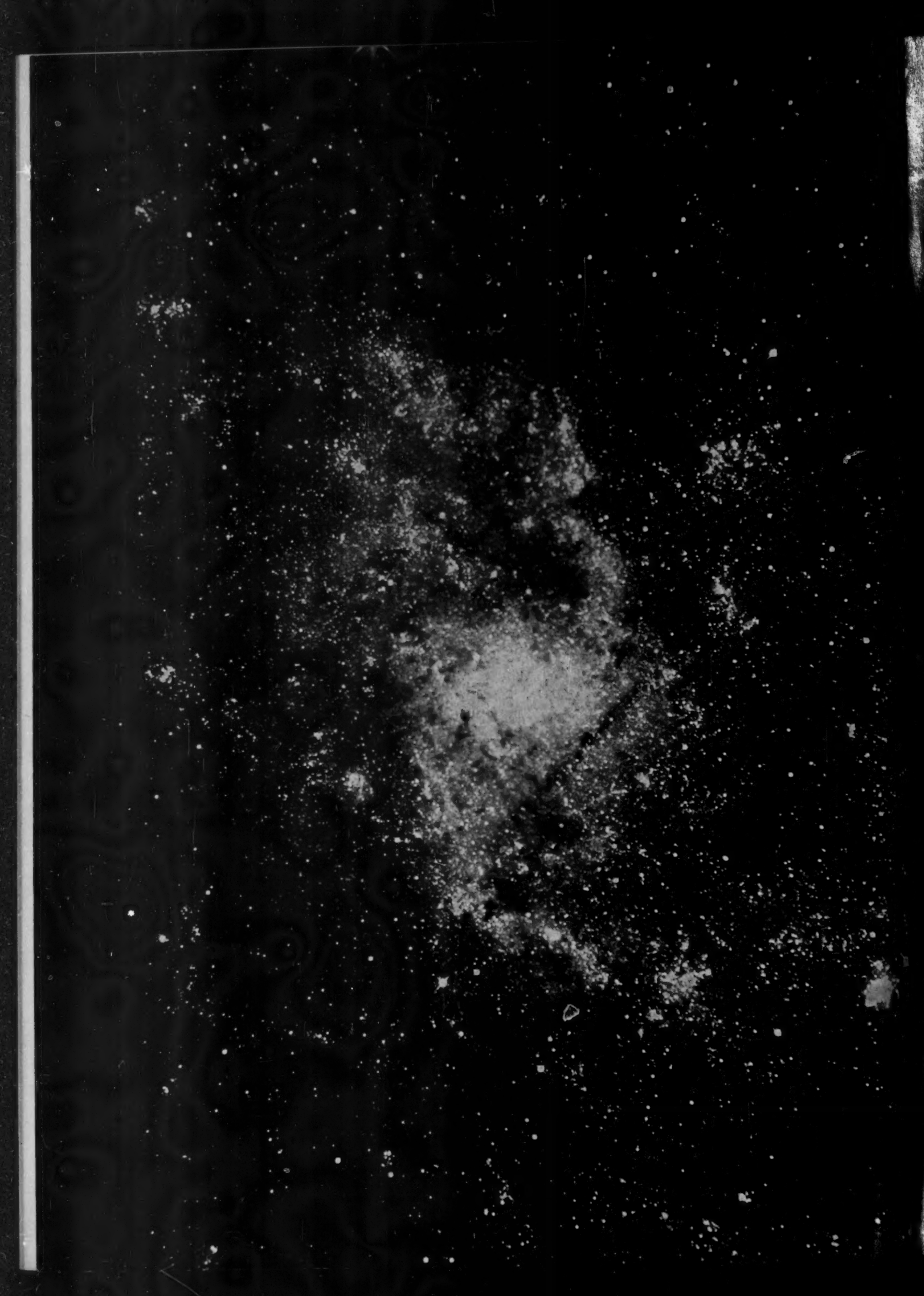
Here the Hayden Planetarium will present a colorful pageant of the development of navigation. From ancient days to the present, man has constantly sought new methods for finding his way over the earth. The early Polynesians, the Columbus age of explorers, the windjammer, the modern flying fortress—each had its own techniques. By means of complicated projection, music, and newly-created effects, the story will be unfolded on the Planetarium sky. Nor will the principles of navigation be neglected in this popular story. New classes in Navigation and Star Identification start November 5th. Each course consists of 10 lectures in the dome of the Planetarium on Tuesdays and Thursdays for five weeks. The fee for each course is $2.50; write to the Hayden Planetarium for an application blank and further information.

★ SCHEDULE BUHL PLANETARIUM

Tuesdays through Fridays.....3 and 8:30 p.m.
Saturdays .....2, 3, and 8:30 p.m.
Sundays and Holidays.....3, 4, and 8:30 p.m.
(Building closed Mondays)

★ STAFF—*Director*, Arthur L. Draper; *Lecturer*, Nicholas E. Wagman; *Business Manager*, Frank S. McGary; *Public Relations*, John J. Grove; *Curator of Exhibits*, Fitz-Hugh Marshall, Jr.

★ SCHEDULE HAYDEN PLANETARIUM

Mondays through Fridays.....2, 3:30, and 8:30 p.m.
Saturdays .....11 a.m., 2, 3, 4, 5, and 8:30 p.m.
Sundays—Mutual Network Broadcast—Coast-to-Coast..9:30–10 a.m.
Sundays and Holidays.....2, 3, 4, 5, and 8:30 p.m.

★ STAFF—*Honorary Curator*, Clyde Fisher; *Curator*, William H. Barton, Jr.; *Assistant Curators*, Marian Lockwood, Robert R. Coles (on leave in Army Air Corps), John Ball, Jr.; *Staff Assistant*, Fred Raiser; *Lecturers*, Asa Tenney, Charles H. Coles.